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ABSTRACT

This teacher's guide accompanies the solid-state electrical controls curriculum, an instructional program designed to upgrade the skills of coal mine electricians who work with mining equipment that has solid-state electrical controls. The guide describes the program components and suggests several implementation sequences for the twenty-one competency based units of instruction included in the program. Instructions and answer keys for the program pretest are provided, and specific directions for teaching each unit are also included. (BM)

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ED150334

TEACHER GUIDE

"UPGRADING MINE ELECTRICIANS IN THE USE OF SOLID STATE ELECTRICAL CONTROLS"

Prepared by:

West Virginia Department of Education

Bureau of Vocational, Technical and

Adult Education

U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE NATIONAL INSTITUTE OF EDUCATION

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Contract No. OEG-G007603756.

PREFACE

It is with the greatest pleasure that we bring you another West Virginia competency based education (CBE) curriculum. The curriculum for "Upgrading Mine Electricians in the Use of Solid-State Electrical Controls" has been developed during July 1, 1976 - June 30, 1977 by:

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Eastern Associated Coal Corp.
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The Bureau of Vocational, Technical and Adult Education, State Department of Education, began advocating CBE curriculum in 1974. Since that time we have produced state CBE curricula in a number of additional occupational areas. We also have a number of CBE curricula currently in the process of being developed and/or field-tested.

I trust this Solid State Electronics curriculum will help your program. Any suggestions you may have for improving this curriculum

may be sent to the curriculum lab. Through this and other feedback we plan to continually update our curriculum. Additional copies of this curriculum are available at the Vocational Curriculum Laboratory, Cedar Lakes Conference Center, Ripley, West Virginia, 25271.

Clarence Burdette
Assistant State Superintendent of Schools
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Adult Education

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INTRODUCTION

This document is the Teacher's Guide, which accompanies the Solid-State Electrical Controls Curriculum. The curriculum was developed in 1976-77 through the use of Part C - Vocational Research Funds. The funds were made available to the Bureau of Vocational, Technical and Adult Education in the West Virginia Department of Education through the Bureau of Occupational and Adult Education for Project Number 498AH60177 entitled "Development of a Curriculum for Upgrading Mine Electricians in the Use of Solid-State Electrical Controls." The Guide contains sections on program development, competency statements, format, implementation sequences, equipment and material requirements, program pretests, and implementation guidelines for each Student Competency Sheet.

Program Purpose

The primary purpose of the research and demonstration activities for this project was to develop and field test an instructional program to upgrade the skills of coal mine electricians for working with mining equipment that has solid-state electrical controls. The trend today shows that solid-state electrical controls are one of the most rapidly emerging areas of technology in modern coal mining operations. The need for upgrading skills of employed electricians due to advancing technology and the need to train new personnel in an expanding industry require training materials and programs. Based on an extensive review, such materials and programs were not available for job-related training for coal mine electricians in the area of solid-state electrical controls for mine machinery.

Intended Uses

Intended uses of the Solid-State Electrical Controls Curriculum should be viewed within these major parameters: (1) The current effort is considered a "first course." Trainees who complete the course would next benefit by attending training sessions conducted by specific equipment manufacturers. (2) Because solid-state controls represent an emerging technologic application to mining, continual upgrading of trainee skills is considered a necessity.

Given the parameters noted above, the Solid-State Curriculum can best be used by having qualified vocational-technical instructors offer the program at area vocational/technical centers. Also, because the equipment is portable and the curriculum materials complete and self-contained, the program could be conducted by a qualified trainer at a particular mining company location or a central training facility used by a mining company.

Major Developmental Activities

Major project developmental activities were as follows:

1. An advisory committee, representative of coal operators and equipment manufacturers, was utilized to give direction and evaluative input.
2. Competency statements were written by vocational instructors and reviewed and validated by representatives from coal mining companies.
3. Curriculum development was the primary responsibility of three vocational instructors whose area of expertise was mine electricity. Review and input were accomplished by using the established advisory committee.
4. With the assistance of curriculum writers and manufacturer representatives, specification and purchase of specially designed solid-state instructional panels were the responsibility of project directors.

5. Pilot testing of the first draft of the curriculum was accomplished by having the lead curriculum writer serve as the instructor and a group of 12 mine electricity instructors and coal company trainers serve as students.
6. Following evaluation of the pilot test results, curriculum revision was completed by the original curriculum writers.
7. Field testing of the second draft of the curriculum was accomplished by having one of the instructors who had participated in the pilot test serve as the instructor and 12 mine electricians serve as the students.
8. Following evaluation of the field test results, curriculum revision was completed.

Program Components

The major components of the Solid-State Curriculum are as follows:

1. This Teacher's Guide.
2. Twenty-one instructional units. Each unit contains one or more Student Competency Sheets with necessary attachments of handouts, study questions, experiments, troubleshooting problems, and criterion-referenced tests. There are no textbooks or other reference materials for the program.
3. A program pretest. (Discussed in a section of this Guide.)
4. The necessary equipment and materials. (Discussed in separate sections of this Guide.)
5. A final technical report explaining the development of the program.

COMPETENCY STATEMENTS

Competency statements form the heart of the Competency Based Education (CBE) format used in the Solid-State Curriculum. The CBE format is discussed in the next section of this Guide. The competency statements contained in the program are as follows:

Unit 01: Meters, Part I

Competency Statement: Identifies the general characteristics of the multimeter (VOM) and uses the multimeter (VOM) as an ohmmeter to check resistance.

Unit 01: Meters, Part II

Competency Statement: Uses the multimeter as a voltmeter to measure AC and DC voltage.

Unit 01: Meters, Part III

Competency Statement: Uses multimeter (VOM) as an ammeter.

Unit 02: Resistors

Competency Statement: Identifies resistors and their symbols and explains their uses and characteristics.

Unit 03: Capacitors, Part I

Competency Statement: Identifies capacitors and symbols and explains capacitor operation.

Unit 03: Capacitors, Part II

Competency Statement: Explains uses of capacitors.

Unit 04: Inductors, Part I

Competency Statement: Explains basic principles of current-carrying conductors.

Unit 04: Inductors, Part II

Competency Statement: Explains how inductors are used and identifies and draws their symbol.

Unit 04: Inductors, Part III

Competency Statement: Explains the operation of inductors in a circuit.

Unit 05: Diodes, Part I

Competency Statement: Identifies diodes and their symbols and explains their function.

Unit 05: Diodes, Part II

Competency Statement: Explains uses of diodes.

Unit 06: SCR, Operation

Competency Statement: Explains SCR operation.

Unit 06: SCR, Voltage Control

Competency Statement: Explains function and use of the SCR for voltage control.

Unit 06: SCR, Identification and Symbol

Competency Statement: Identifies SCRs and their symbol.

Unit 07: Triggering Circuits

Competency Statement: Explains characteristics of triggering circuits.

Unit 08: Schematics: DC Symbols

Competency Statement: Identifies DC component symbols and explains use of components.

Unit 08: Schematics: DC Circuit Tracing

Competency Statement: Traces current flow in a DC schematic and explains operation.

Unit 09: Schematics: AC Symbols

Competency Statement: Identifies AC symbols and explains use of components.

Unit 09: Schematics: AC Circuit Tracing

Competency Statement: Traces current flow on an AC schematic and explains operation.

Unit 10: Schematics: AC/DC Solid-State

Competency Statement: Traces pulse through an AC/DC solid-state system and explains operation.

Unit 11: Circuit Connections: AC/DC Solid-State

Competency Statement: Interconnects solid-state components and devices on an AC/DC solid-state panel.

Unit 12: Control Positions and Terminal Voltages

Competency Statement: Identifies all operating positions and terminal voltages based on meter readings for an AC/DC solid-state panel.

Unit 13: Troubleshooting: Operator's Remarks

Competency Statement: Interprets operator's remarks and specifies probable cause(s) for malfunctions.

Unit 14: Troubleshooting: AC/DC Solid-State

Competency Statement: Troubleshoots AC/DC solid-state panel by specifying probable causes for malfunctions, recommending service procedures, and locating and correcting faults.

Unit 15: Schematics: Solid-State, Battery-Powered

Competency Statement: Traces pulse through a battery-powered, solid-state system and explains operation.

Unit 16: Belt Starter Components

Competency Statement: Identifies components on a belt starter.

Unit 17: Schematics: Belt Starter

Competency Statement: Traces control and power circuit current and explains operation.

Unit 18: Circuit Connections: Belt Starter

Competency Statement: Connects solid-state controllers, motors and power sources for belt starter.

Unit 19: Troubleshooting: Belt Starter

Competency Statement: Troubleshoots AC solid-state belt starter panel by specifying probable causes for malfunctions, recommending service procedures, and locating and correcting faults.

Unit 20: Solid-State, Battery-Powered: Components

Competency Statement: Identifies and explains function of components on solid-state, battery-powered panel.

Unit 21: Solid-State, Battery-Powered: Troubleshooting

Competency Statement: Troubleshoots solid-state, battery-powered panel by specifying probable causes for malfunctions, recommending service procedures, and locating and correcting faults.

IMPLEMENTATION SEQUENCES

This section contains a discussion about the implementation sequences that are recommended for the Solid-State Curriculum. These recommendations are based in part on decisions that were made when the Curriculum was written and in part on the limitations imposed on implementation as a result of availability of major training hardware. Associated with the recommended sequences are the following assumptions:

1. Maximum enrollment would be 12 students.
2. There would be one instructor.
3. Space requirements, as listed in the next section of this Guide, would be met.
4. Power requirements, as listed in the next section of this Guide, would be met.
5. One of each of the major training panels, as described in the next section of this Guide, would be available.
6. One circuit board for experiments, as described in the next section of this Guide, would be available for every four students.
7. Each student would have a VOM.
8. One handtool set, as described in the next section of this Guide, would be available for every four students.

Initial Sequence

It is recommended that students complete Units 01 through 07 in sequence. These units have been written in a "building block" fashion. In addition Unit 01: Meters, Part I can be used along with a written exercise entitled "Introduction to Competency Based Education (CBE) and How to Use the Course Materials." Figure I graphically shows this sequence.

Sequence A

Sequences A, B, and C are structured around the three major training panels. Approximately one third of the students could pursue each sequence as listed. Sequence A has the following features and is shown graphically in Figure II.

1. Unit 08, both parts, is completed after Units 01 through 07.
2. Units 15 and 20 on Solid-State, Battery-Powered equipment are completed next.
3. Unit 13: Troubleshooting: Operator's Remarks is completed prior to Unit 21 on Solid-State, Battery-Powered: Troubleshooting.
4. Students would then complete Units 09, 16, 17, 18, and 19. This is a sequence on AC-powered equipment with solid-state controls.
5. Finally the students would complete Units 10, 11, 12, and 14. This is a sequence on AC/DC-powered equipment with solid-state controls.

Sequence B

Sequence B has the following features and is shown graphically in Figure III.

1. Unit 09, both parts, is completed after Units 01 through 07.
2. Units 16, 17, and 18 on AC-powered, solid-state equipment are completed next.
3. Unit 13: Troubleshooting: Operator's Remarks is completed prior to Unit 19 on troubleshooting AC-powered, solid-state equipment.
4. Students would then complete Units 08, 10, 11, 12, and 14. This is a sequence on AC/DC-powered equipment with solid-state controls.
5. Finally, the students would complete Units 15, 20, and 21. This is the sequence on battery-powered, solid-state equipment.

Sequence C

Sequence C has the following features and is shown graphically in Figure IV.

1. Units 08 and 09, both parts of each, are completed by the students after Units 01 through 07.
2. Units 10, 11, and 12 on AC/DC-powered, solid-state equipment are completed next.
3. Unit 13: Troubleshooting: Operator's Remarks is completed prior to Unit 14: Troubleshooting AC/DC, Solid-State.

4. Students would then complete Units 15, 20, and 21. This is the sequence on battery-powered, solid-state equipment.
5. Finally, the students would complete Units 16, 17, 18, and 19. This is the sequence on AC-powered, solid-state equipment.

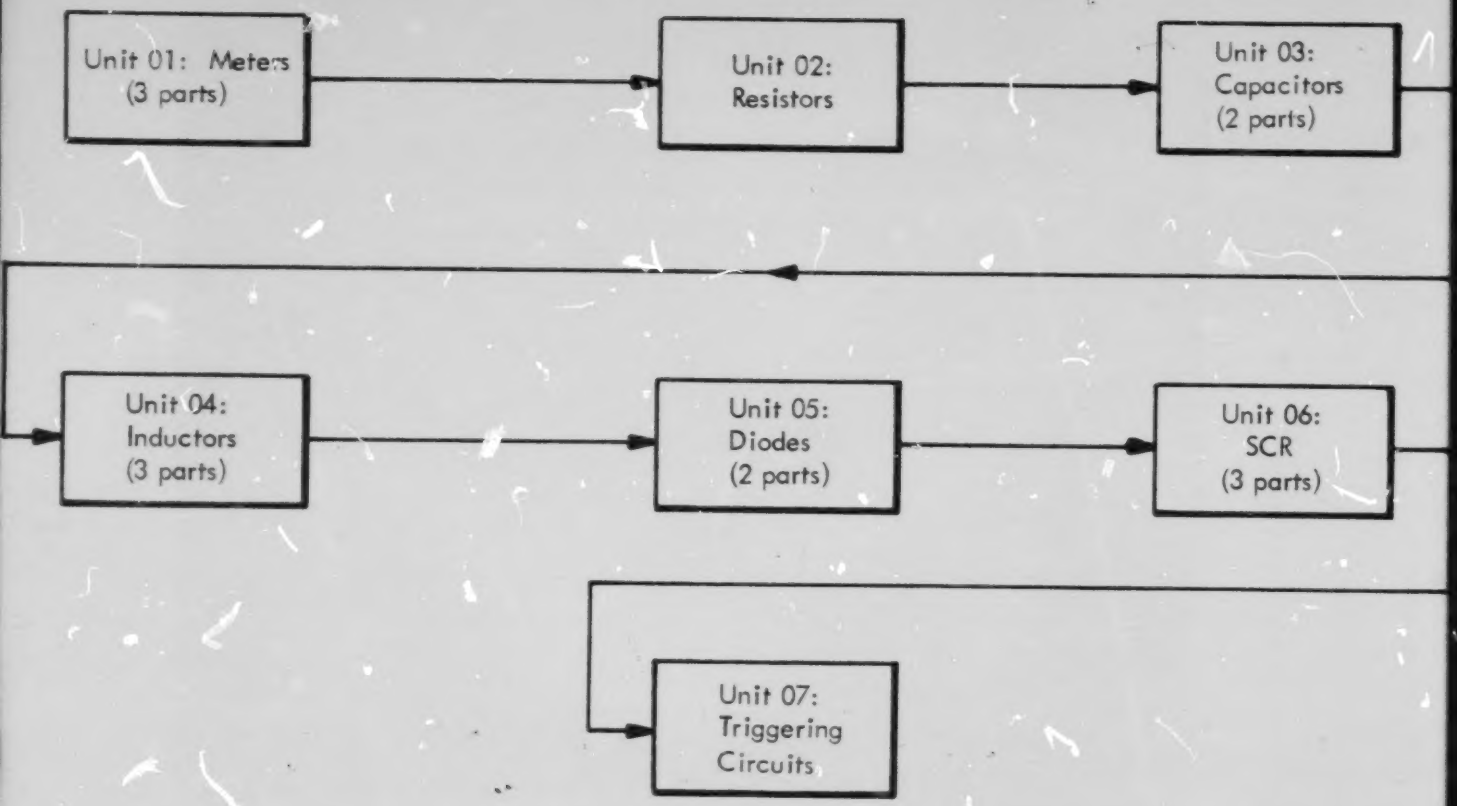


Figure 1 - Initial Sequence

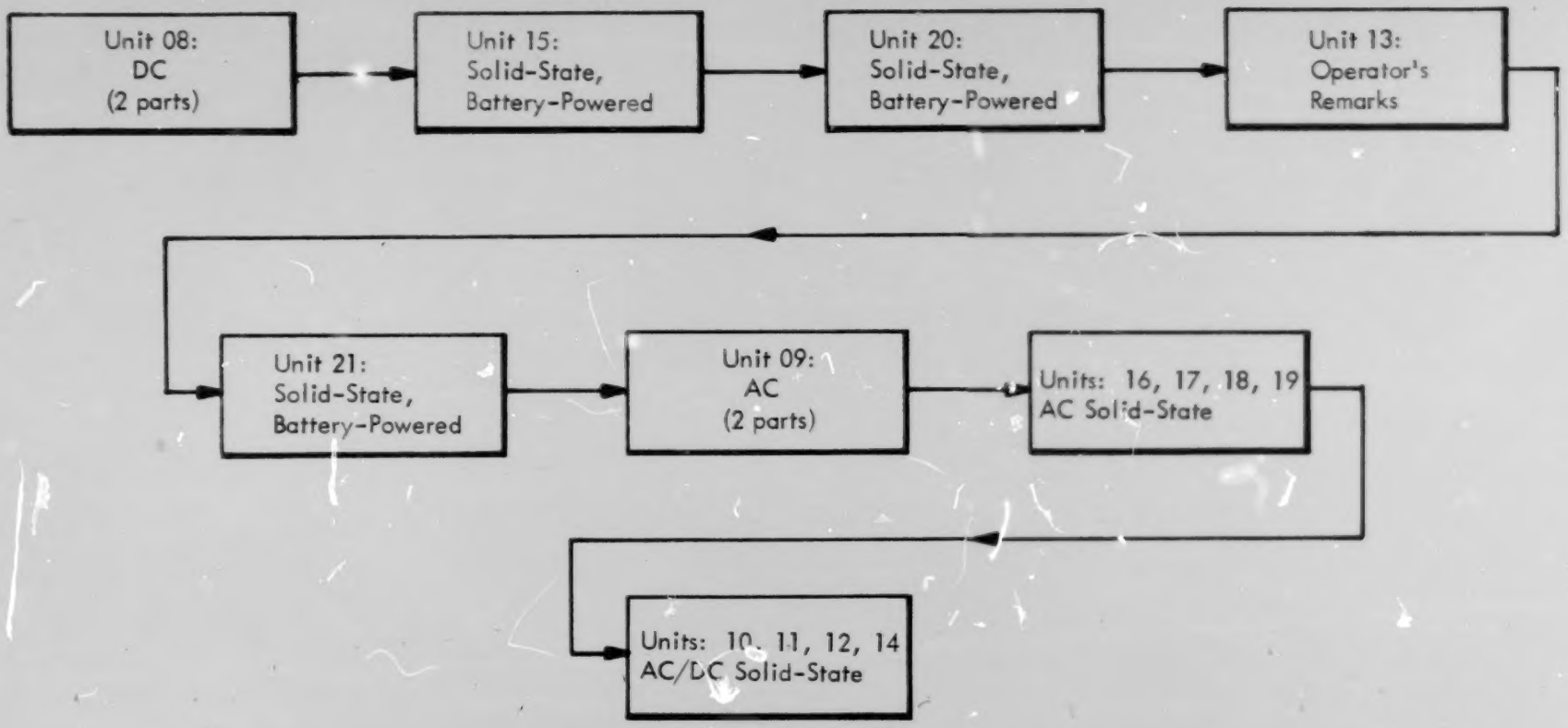


Figure II - Sequence A

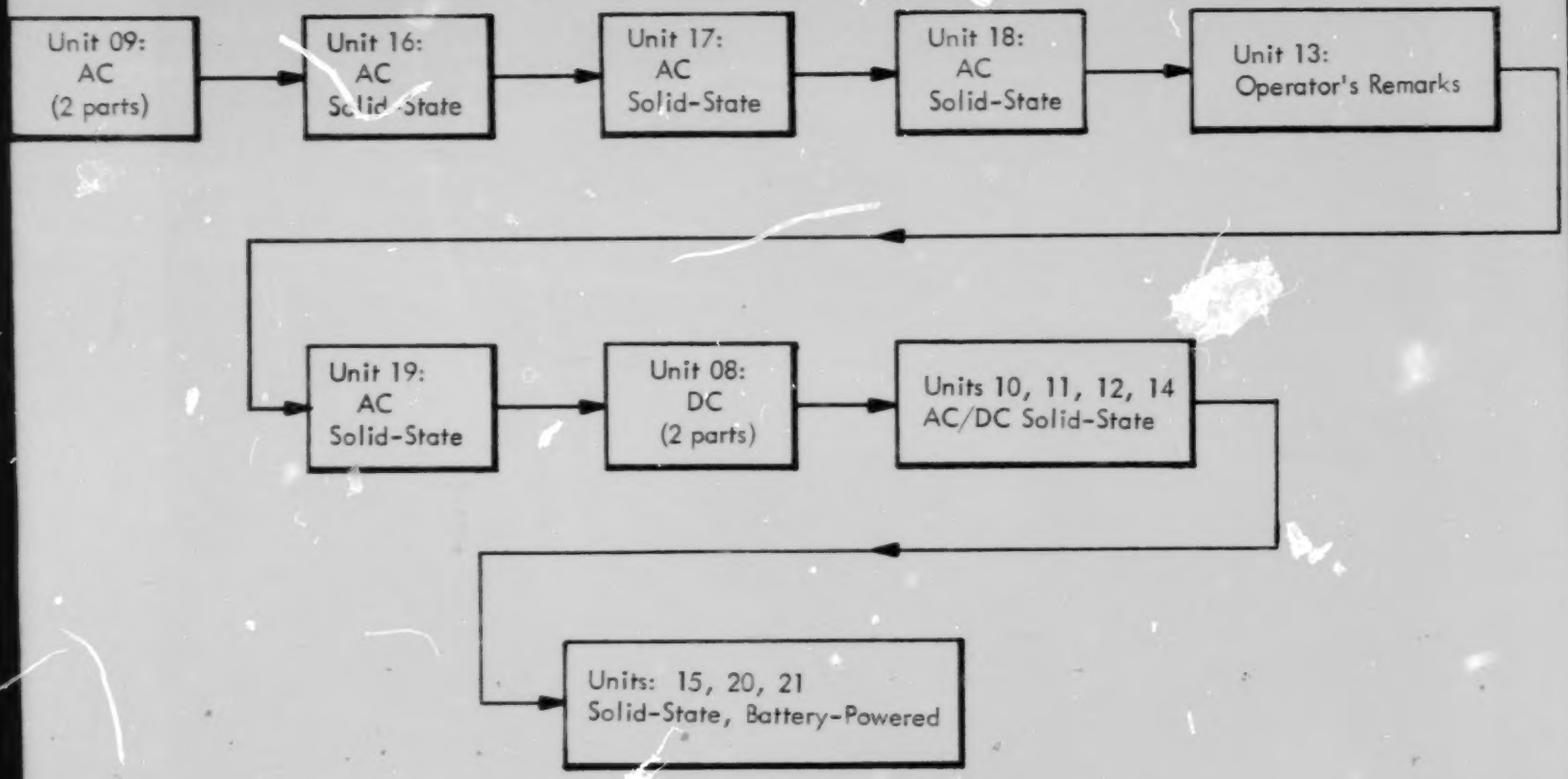


Figure III - Sequence B

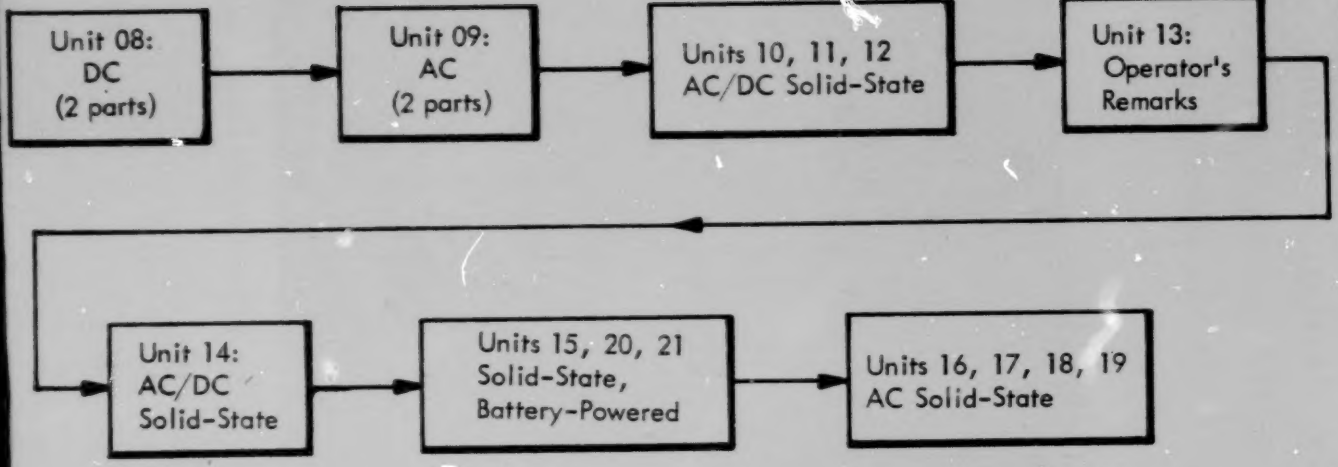


Figure IV - Sequence C

HARDWARE AND MATERIALS REQUIREMENT

This section contains a listing of the hardware and materials requirement for the Solid-State Curriculum. The first subsection lists all materials, not associated with use of one of the three major training panels, required for implementation of each unit. No "paper" materials, other than schematics which need to be purchased by the user, are listed. The second subsection contains a bill of materials for each of the main training panels as well as the power and space requirements for each. Materials associated with the use of the panels are also listed.

Materials for Each Unit

Throughout the curriculum students use a VOM and hand tools. Each student should have a VOM. The VOM referred to throughout is the Micronta Multitester. There should be a set of handtools for each group of four students. The set includes the following: combination pliers, side cutter pliers, flat blade screwdrivers (3), phillips screwdrivers (3), adjustable wrench, and hex wrench set.

1. Unit 01: Meters, Part I
    a. VOM
    b. Assortment of ten resistors, "good" and "bad"; various sizes.

2. Unit 01: Meters, Part II
   a. VOM

3. Unit 01: Meters, Part III
   a. VOM
   b. Circuit board for Experiment #1 or the following:
      battery, 6 volt
      resistor, 10,000 ohm (variable)
      wire leads, two

4. Unit 02: Resistors
   a. Assortment of at least twelve resistors (wire wound, carbon, potentiometer, rheostat); may be "good" or "bad"; three sizes of each type.

5. Unit 03: Capacitors, Part I
   a. Assortment of at least ten capacitors; may be "good" or "bad"; various sizes, shapes, and capacities.
   b. The following for Experiment #1:
      VOM
      capacitor (large canister type)
      battery, 6 volt
      wire leads, two
   c. The following for Experiment #2:
      assortment of ten capacitors, "good" or "bad"

VOM

battery, 6 volt

wire leads, two

6. Unit 03: Capacitors, Part II

   a. Circuit board for Experiment #1 or the following:

      VOM

      two capacitors (10 MFD and 100 MFD)

      two resistors (100 K-ohm and 1 M-ohm)

      battery, 6 volt

      wire leads, two

7. Unit 04: Inductors, Part I

   a. The following for Demonstration #I:

      galvanometer

      coil

      horseshoe magnet

   b. The following for Demonstration #II:

      growler

      coil

      light bulb

8. Unit 04: Inductors, Part III

   a. Circuit board for Experiment #1 or the following:

      VOM

      variable DC power supply, 0-120 volts

switch
neon bulb
resistor
inductor

9. Unit 05: Diodes, Part I
   a. Assortment of at least ten diodes; may be "good" or "bad"; various sizes.
   b. For Experiment #1 an assortment of five diodes; should be "good" and "bad"; various sizes.

10. Unit 05: Diodes, Part II
   a. Circuit board for Experiment #1 or the following:
      diodes, four
      transformer, tapped winding
      lamp
      small leads, five or six
      VOM

11. Unit 06: SCR, Identification and Symbol
   a. Assortment of at least ten SCR's; may be "good" or "bad"; various sizes and shapes.

12. Unit 06: SCR, Operation
   a. Circuit board for Experiment #1 or the following:
      VOM

SCR

battery

lamp

resistor, variable

push button switch

short leads, five or six

13. Unit 07: Triggering Circuits
    a. Circuit board for Experiment #1.
    b. Circiut board for Experiment #2.
    c. Circuit board for Experiment #3.

14. Unit 10: Schematics: AC/DC - Solid State
    a. WD 3536-36 from Joy Manufacturing Company

15. Unit 11: Circuit Connections: AC/DC - Solid State
    a. WD 3536-36 from Joy Manufacturing Company
    b. VOM
    c. Handtools

16. Unit 12: Control Positions and Terminal Voltages
    a. WD 3536-36 from Joy Manufacturing Company

17. Unit 14: Troubleshooting: AC/DC - Solid State
    a. WD 3536-36 from Joy Manufacturing Company
    b. VOM
    c. handtools

18. Unit 18: Circuit Connections: Belt Starter

    a. VOM

    b. handtools

19. Unit 19: Troubleshooting: Belt Starter

    a. VOM

    b. handtools

20. Unit 21: Solid State, Battery Powered: Troubleshooting

Training Panels

The bill of materials given below is for the battery powered, solid state training panel. The power requirement is 120 VAC and the space requirement is 10' X 10'.

Component #	Quantity	Component Description
D3654-3x1	1	.Panel Assembly
A3467	1	.Coil Sevcon
A3461	1	.Logic Unit Sevcon
A5100	1	.SCR Panel Sevcon
A2785	1	.Circuit Breaker Westinghouse
A642x5	1	.Handle S & S
A600x6	1	.Arm S & S
A3460	1	.Switch Sevcon
B3406-5	1	.Shaft S & S
A642	1	.Switch Handle S & S
A641	1	.Switch Electro-Switch
A4431	1	.Switch OEM-Controls
A4464	1	.Shaft S & S
B4474	1	.Mounting Pad S & S
A3188x12	2	.Fuse
A6373	1	.Commutating Coil Sevcon
A6374	1	.Filter Capacitor Sevcon

Component #	Quantity	Component Description
A6375	2	.Ballast Resistor Sevcon
A6376	1	.Current Limit Coil Sevcon
A6377	1	.Rectifier Westinghouse
A2400x92	1	.1/8 Horsepower Compound Wound Motor Reliance Electric
D3654-3	1	.Panel Board S & S
A2480x4	1	.Contactor Sq-D
A2481x3	3	.Contactor, 200A Sq-D
A2480x2-6	1	.Interlock Kit/L. H. Sq-D
A2480x2-5	1	.Interlock Kit/R. H. Sq-D
A3530	3	.Coil Supp. Network Sevcon
A2479x3-1	1	.Solid State Timer Sq-D
A2537	6	.Fuse Clip Allen Bradley
A3188x1	2	.Fuse, Ktk-5 Allen Bradley
A3188x2	4	.Fuse, Ktk-20 Allen Bradley
A2541	2	.Retainer Clip Allen Bradley
A2540	1	.Plate Allen Bradley
A2538	.10	.Terminal Block Allen Bradley

The bill of materials given below is for the belt starter training panel. The power requirement is 220/440 VAC, three phase, and the space requirement is 10' X 10'. The user also needs to provide an AC motor.

Component Description	Quantity
Pan, self support 30" X 36" X 3/4"	1
Main circuit breaker, 480 VAC	1
Control transformer, 480/240 to 120 VAC @ 200VA	1
Fuse holder, W/2A, 600 V fuse	2
Control card rack	1
SCR, 1500 volts, 80A RMS	3
Capacitors, 2-0 uf, 600 volts, capacitor in series	3
Resistors, 30 ohm, 10 W	3
Metal oxide varistors, 480 volts	3
Metal oxide varistors, 120 volts	1
Resistors, 15 K, 10 W	3
Lamps, transformer operated, 120 VAC, clear vapor	3

Component Description	Quantity
Selectro switch, three positions	1
Relays, 600 volts, 120 VAC coil to N.O. contacts	2
Terminal block, three point	1
Terminal block, twelve point	1
Current transformer, 200:5	1
Time delay relay, on delay, 600 volt contact, 1 N.C. time and 1 N.O. inst., 120 VAC coil	1
Pilot lamps, 120 VAC with neon bulbs	6
Bracket	1

The bill of materials given below is for the AC/DC - solid state training panel. The power requirement is 440/550 VAC, three phase, and the space requirement is 10' X 15'.

Component #	Component Description	Quantity
A202K1CA	Contactor, w/120 V coil	4
A202K4CA	Contactor, w/120 V coil	7
-	Coil, Size 4 contactor, 120 V	1
EHB	Circuit Breaker, 30 A, 3 Pole, 480 V	3
EB	Circuit Breaker, 10 A, 3 Pole, 250 V	2
L56	Electrical Interlock	13
M-33-2A	Mechanical Interlock	5
M-35-2A	Mechanical Interlock	1
-	Fuse Holder (Double), 10 A 250 V w/fuses	1
-	Foot Switch, SIP, N.O. Contacts	1
-	Emergency Stop Switch, Nemal, w/red mushroom head	1
AN42A	Overload	3
AN21P	Overload	4
-	Heaters	9
601564-22	Power Transformer	1
600033-149	Control Transformer	1
601849-2	SCR Bridge	1
601848-1	SCR Firing Package	1
570086-14	Fanning Strip	1
570086-15	Fanning Strip	1

Component #	Component Description	Quantity
570086-16	Fanning Strip	1
570086-10	Fanning Strip	1
601506-133	Control Switch	1
601506-178	Pump and Traction Switch	1
601506-179	Cutter Motor Switch	1
601506-182	Conveyor Switch	1
601839-26	Logic Panel	1
534969-3	Relay	2
-	Light Socket, Screw-in, 300 V	8
-	Light Bulbs, 300 V 150 W	8
-	Solid Wire, #10, red	50'
-	Solid Wire, #14, white	50'
-	Terminals, #10, insulated	1 box
-	Terminals, #14, insulated	1 box

COMPETENCY BASED EDUCATION (CBE) FORMAT

The Solid-State Electrical Controls Curriculum has been developed by following procedures and using a format referred to as competency based education (CBE). This section is a short discussion on three aspects of CBE: (1) developmental procedures, (2) curriculum format, and (3) generalized implementation procedures. A sample of the curriculum is attached to this section as Exhibit I.

CBE is not a new approach to curriculum development and vocational instruction, but rather it is a group of techniques and methods that have proven successful in various training settings. From a curriculum development standpoint, CBE means the following things:

1. The curriculum is based on and written around a listing of competency statements that are occupationally relevant. Competency statements are nothing more than a listing of knowledge, attitudes, and skills demonstrated by an incumbent worker. In our case competency statements are those things that a competent mine electrician knows and does on the job when dealing with equipment that has solid-state electrical controls.

2. Once competency statements have been written and validated through a review by industry representatives, performance objectives are written for each statement.

Performance objectives state what, under what conditions, and how well a student must perform in the training setting. The objectives are written to "mirror" the competency statements as closely as possible.

3. Another way to look at performance objectives is that they describe a test situation. They describe the situation that will be used to test whether a student is competent -- whether he or she can perform as stated in the competency statement. Test situations (examinations) are written for each performance objective. They may be a list of questions to answer, situations to respond to, or actions to be performed. What the test is like is completely dependent on how the performance objective is written.

4. The major reason in CBE curriculum development for writing competency statements, performance objectives and test situations is the expectation that each student demonstrate the type and level of performance considered to be competent. If each student must demonstrate mastery, then there must be various learning activities that assist the student in attaining that mastery. This is the reason why written learning activities and supplemental learning materials are written as part of the CBE curriculum.

The Solid-State Curriculum has been developed in line with the major developmental activities listed above. Look at Exhibit I to this section as you read the discussion below.

The Solid-State Curriculum consists of 21 Units. A Unit may have one or more Student Competency Sheets. There are 31 Student Competency Sheets (SCSs) in the Curriculum. The SCSs have been written for the student to read and follow. They contain the following features:

1. A Unit number and title.
2. A Competency Statement.
3. A Performance Objective. The Action portion of a Performance Objective tells the student what he or she needs to do to demonstrate competence. The Conditions portion of each Objective tells the student what he or she will need or have to work with during the test situation. The Standards portion of each Objective states how well the student must perform.
4. A list of Learning Activities. The student is expected to read these. By following the Learning Activities, the student will know what to get, where to go, and what to do in the training areas. The Activities let the student know when the assistance of the instructor is required. The final Learning Activity in each case is instructions for the student to complete the Examination associated with the SCS.
5. Attachments (an SCS may have several things attached to it).
   a. In the case of Performance Objectives that require questions to be answered or similar activities, a written Examination is included.

The Answer Sheets for these Examinations are contained in this Guide. In some cases where the Performance Objective calls for a performance activity, a written description and procedural format is included for the student. In other cases as in Exhibit I, the Examination is sufficiently well explained by the Performance Objective, and no written Examination is included in the SCS.

b. Almost all SCSs have Handouts attached. These Handouts make the SCS self-contained. No textbooks or reference books are needed. Each Handout has either a series of questions at the end or exercises to be performed. Answer Sheets for the Handouts are included in this Guide.

c. Diagrams may be attached. Diagrams are both unmarked, which allows for practice, and marked, which allows the students to follow a procedure while reading.

d. Experiments may be attached. If an Experiment has questions in it, the answers will be found in this Guide.

A generalized implementation procedure for an SCS is as follows (this listing assumes that you, as the instructor, have read the SCS and the associated implementation guidelines contained in this Guide).

1. The student reads the complete SCS.
2. If pretests are used in the implementation procedure, the student may decide to take a pretest.
3. In most instances Learning Activities may be completed in any order based on the student's needs. Students having limited background knowledge and experience or who are experiencing difficulty with the curriculum content should be encouraged to complete the Learning Activities in order.
4. In some instances the student can self-check responses to Learning Activities. In other cases, which are clearly identified, you will need to check procedures and responses.
5. The student should request that the Examination be given as a posttest.
6. Both pre- and posttests are scored immediately. If the student does not attain competency on the posttest, you should assign Learning Activities accordingly.

STUDENT COMPETENCY SHEET #1

UNIT: 11 CIRCUIT CONNECTIONS: AC/DC SOLID STATE

COMPETENCY STATEMENT: INTERCONNECTS SOLID STATE COMPONENTS AND DEVICES ON AN AC/DC SOLID STATE PANEL

PERFORMANCE OBJECTIVE:

ACTION: YOU WILL INTERCONNECT SOLID STATE COMPONENTS AND DEVICES ON AN AC/DC SOLID STATE PANEL AND TAKE METER READINGS.

CONDITIONS: YOU HAVE 30 MINUTES TO DO ALL WORK. YOU HAVE THESE ITEMS TO WORK WITH: AN AC/DC SOLID STATE PANEL, REPLACEMENT SOLID STATE COMPONENTS AND DEVICES, HAND TOOLS, VOM, SCHEMATIC DIAGRAMS, AND WIRING DIAGRAMS.

STANDARD: THIS IS HOW WELL YOU MUST DO:

1. AFTER YOU HAVE COMPLETED THE INTERCONNECTIONS, THE METER READINGS MUST BE LIKE THOSE ON THE DIAGRAMS.
2. AFTER YOU HAVE COMPLETED THE INTERCONNECTIONS, THE PANEL MUST WORK LIKE IT SHOULD.
3. YOU MUST WORK SAFELY AND NOT DAMAGE TOOLS OR PARTS.
4. YOU MUST GET DONE IN 30 MINUTES.

LEARNING ACTIVITIES:

1. GET STUDENT HANDOUT #1, "KNOW THE PANEL," FROM THE INSTRUCTOR. DO ALL THE THINGS LISTED ON THE HANDOUT.
2. GET STUDENT HANDOUT #2, "KNOW THE INTERCONNECTIONS," FROM THE INSTRUCTOR. DO ALL THE THINGS LISTED ON THE HANDOUT.
3. GET STUDENT HANDOUT #3, "AC/DC SOLID STATE: MAIN INTERCONNECTIONS," FROM THE INSTRUCTOR. DO ALL THE THINGS LISTED ON THE HANDOUT.
4. TELL THE INSTRUCTOR WHEN YOU ARE READY FOR THE EXAMINATION. COMPLETE THE EXAMINATION.

STUDENT HANDOUT #1

UNIT: 11 CIRCUIT CONNECTIONS: AC/DC SOLID STATE

KNOW THE PANEL

DO THESE THINGS:

1. GET THE SCHEMATIC AND WIRING DIAGRAMS FOR THE AC/DC SOLID STATE PANEL. GO TO THE PANEL WITH THE DIAGRAMS. FIND THE FIRING PACKAGE ON THE PANEL AND ON THE DIAGRAMS. ANSWER THESE QUESTIONS:
   A. HOW MANY CONNECTIONS ARE THERE FOR THE FIRING PACKAGE?
   B. WHAT TYPES OF MARKINGS ARE USED TO IDENTIFY THE LEADS FOR THE FIRING PACKAGE?
   C. WHERE ARE THE SCR GATE LEADS FOR THE LEFT MOTOR?
   D. WHERE ARE THE SCR GATE LEADS FOR THE RIGHT MOTOR?
   E. WHAT OTHER COMPONENTS ARE CONNECTED TO THE FIRING PACKAGE?

HAVE YOUR INSTRUCTOR CHECK YOUR WORK.

2. FIND THE LOGIC BOX ON THE PANEL AND ON THE DIAGRAMS. ANSWER THESE QUESTIONS:
   A. HOW MANY CONNECTIONS ARE THERE ON THE LOGIC BOX?
   B. DESCRIBE HOW THE LEADS FOR THE LOGIC BOX ARE IDENTIFIED.
   C. DESCRIBE HOW TO CHANGE THE LOGIC BOX. WHAT CAN BE DONE WITH THE TERMINALS TO MAKE CHANGING EASIER?

HAVE YOUR INSTRUCTOR CHECK YOUR WORK.

3. FIND THE SCR BRIDGE ON THE PANEL AND ON THE DIAGRAMS. ANSWER THESE QUESTIONS:

   A. WHAT WOULD YOU USE TO TELL IF AN SCR WAS "BAD"?

   B. WHAT OTHER COMPONENTS ARE CONNECTED TO THE SCR BRIDGE?

   C. WHAT WOULD BE THE HARDEST THING TO DO IF YOU HAD TO CHANGE AN SCR BRIDGE?

HAVE YOUR INSTRUCTOR CHECK YOUR WORK.

STUDENT HANDOUT #2

UNIT: 11 CIRCUIT CONNECTIONS: AC/DC SOLID STATE

DO THESE THINGS:

1. A PERSON GIVES YOU A LOGIC BOX. ALL LEADS ARE CONNECTED TO THE LOGIC BOX. THE OTHER END OF EACH LEAD IS DANGLING IN THE AIR. YOUR JOB IS TO TELL WHAT EACH LEAD WOULD BE INTERCONNECTED TO. USE YOUR SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, AND THE PANEL.

   A. TERMINAL #2 IS INTERCONNECTED TO
   B. TERMINAL #8 IS INTERCONNECTED TO
   C. TERMINAL #30 IS INTERCONNECTED TO
   D. TERMINAL #65 IS INTERCONNECTED TO
   E. TERMINAL #70 IS INTERCONNECTED TO
   F. TERMINAL #80 IS INTERCONNECTED TO
   G. TERMINAL #110 IS INTERCONNECTED TO
   H. TERMINAL #140 IS INTERCONNECTED TO
   I. TERMINAL #15 IS INTERCONNECTED TO
   J. TERMINAL #10 IS INTERCONNECTED TO

HAVE YOUR INSTRUCTOR CHECK YOUR WORK.

2. A PERSON GIVES YOU A FIRING PACKAGE. ALL LEADS ARE CONNECTED TO THE FIRING PACKAGE. THE OTHER END OF EACH LEAD IS DANGLING IN THE AIR. YOUR JOB IS TO TELL WHAT EACH LEAD WOULD BE INTERCONNECTED TO. USE YOUR SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, AND THE PANEL.

A. TERMINAL #H-3 IS INTERCONNECTED TO
B. TERMINAL #H-6 IS INTERCONNECTED TO
C. TERMINAL #H-9 IS INTERCONNECTED TO
D. TERMINAL #7 IS INTERCONNECTED TO
E. TERMINAL #9 IS INTERCONNECTED TO
F. TERMINAL #10 IS INTERCONNECTED TO
G. TERMINAL #12 IS INTERCONNECTED TO
H. TERMINAL #16 IS INTERCONNECTED TO
I. TERMINAL #18 IS INTERCONNECTED TO
J. TERMINAL #1 IS INTERCONNECTED TO

HAVE YOUR INSTRUCTOR CHECK YOUR WORK.

3. USE YOUR SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, AND THE PANEL TO ANSWER THESE QUESTIONS ABOUT THE SCR BRIDGE.
   A. PHASE B-1 OF THE SCR BRIDGE CIRCUIT BREAKER CONNECTS TO ONE OF THE SCRs. WHERE IS THE GATE LEAD FOR THIS SCR CONNECTED?
   B. PHASE B-2 OF THE SCR BRIDGE CIRCUIT BREAKER CONNECTS TO ONE OF THE SCRs. WHERE IS THE GATE LEAD FOR THIS SCR CONNECTED?
   C. THERE ARE TWO LEADS GOING TO EACH SCR. ONE IS RED AND THE OTHER IS WHITE. WHICH ONE IS THE GATE LEAD?

HAVE YOUR INSTRUCTOR CHECK YOUR WORK.

STUDENT HANDOUT #3

UNIT: 11 CIRCUIT CONNECTIONS: AC/DC SOLID STATE

AC/DC-SOLID STATE: MAIN INTERCONNECTIONS

DO THESE THINGS:

1. TAKE YOUR SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, HAND TOOLS, AND VOM AND GO TO THE AC/DC-SOLID STATE PANEL. PUT THE PANEL THROUGH ALL OPERATING POSITIONS. TAKE ALL METER READINGS AT THE LOGIC BOX. REMOVE AND REPLACE THE LOGIC BOX. HAVE YOUR INSTRUCTOR CHECK YOUR WORK. ENERGIZE THE PANEL. TAKE METER READINGS AND WRITE THEM DOWN. SHOW THEM TO YOUR INSTRUCTOR SO HE CAN TELL IF THE PANEL WORKS THE WAY IT SHOULD.

2. TAKE YOUR SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, HAND TOOLS, AND VOM AND GO TO THE AC/DC-SOLID STATE PANEL. PUT THE PANEL THROUGH ALL OPERATING POSITIONS. TAKE ALL METER READINGS FOR THE FIRING PACKAGE. REMOVE AND REPLACE THE FIRING PACKAGE. HAVE YOUR INSTRUCTOR CHECK YOUR WORK. ENERGIZE THE PANEL. TAKE METER READINGS AND WRITE THEM DOWN. SHOW THEM TO YOUR INSTRUCTOR SO HE CAN TELL IF THE PANEL WORKS THE WAY IT SHOULD.

3. TAKE YOUR SCHEMATIC DIAGRAMS, WIRING DIAGRAMS, HAND TOOLS, AND VOM AND GO TO THE AC/DC-SOLID STATE PANEL. PUT THE PANEL THROUGH ALL OPERATING POSITIONS. TAKE ALL METER

READINGS FOR THE SCR BRIDGE. REMOVE AND REPLACE THE SCR BRIDGE. HAVE YOUR INSTRUCTOR CHECK YOUR WORK. ENERGIZE THE PANEL. TAKE METER READINGS AND WRITE THEM DOWN. SHOW THEM TO YOUR INSTRUCTOR SO HE CAN TELL IF THE PANEL WORKS THE WAY IT SHOULD.

PROGRAM PRETEST

Based on input from the advisory committee, representatives of coal companies, and vocational instructors, a program pretest was developed to accompany the Solid-State Curriculum. According to these personnel approximately 20% of the electricians working for coal companies could be expected to be involved with servicing mine equipment that had solid-state electrical controls. Also, it was generally agreed that many of these electricians did not have enough background in servicing equipment with conventional AC and DC controls to benefit from a training program dealing with solid-state electrical controls.

As a result of this input, a comprehensive program pretest dealing with conventional AC and DC controls was developed. Many items on the test parallel the types included on the West Virginia Department of Mines certification examination for underground mines. Meter usage and reading is stressed. Component identification is included. Also, there is a section on electrical print reading. Many items deal with safety practices as they apply to the mine electrician.

The test is divided into various sections. Because of its length it is recommended that the test be administered in two or three sittings. Be sure to review Section M prior to administering the test. You will need to prepare the necessary display of conventional components. The components needed are as follows:

1. Mercury tube
2. AC contactor
3. DC contactor
4. AC heater
5. AC or DC operating coil
6. DC overload
7. AC interlock
8. Series starting resistor
9. Current transformer
10. 3 ohms circuit breaker

The answers to the test are attached to this section of the Guide.

Though data could be collected so that the pretest may be used as a program screening device, this has not been done to date. The following information may be gained from an examination of test results.

1. Low scores may indicate that a person has not fully developed the skills to use the VOM. Extra time may be needed in Unit 01.
2. The test may indicate an inability to read electrical prints. Extra time may be needed in Units 08 and 09.
3. Basic knowledge of circuit functioning for AC and DC parallel and series circuits may be lacking. If this is the case, the student may experience difficulty with Units 07, 10, 15, and 16.
4. Indications of a lack of a systematic approach to troubleshooting procedures may be shown. If this is the case, the student may experience difficulty with Units 14, 19, and 21.

Finally, this statement is repeated: There is not enough information available to use this test to screen persons out of the Solid-State Curriculum.

ANSWER KEY

PART A

1. D
2. A
3. C
4. C
5. SERIES, 40 OHMS
6. PARALLEL, 2 OHMS
7. 11 OHMS
8. A-9, B-5, C-2, D-1, E-12, F-10, G-7, H-6, I-4, J-8
9. A
10. C

PART B

11. C
12. C
13. C
14. C
15. D
16. A
17. B
18. A
19. A
20. A
21. B

PART C

22. D
23. A
24. B
25. C
26. A
27. B
28. B
29. A
30. A
31. A

PART D

32. A

33. B

34. D

35. B

36. DELTA-DELTA, WYE-WYE, DELTA-WYE, WYE-DELTA

37. APPROXIMATELY 208

38. A

39. VOLTAGE AT MOTOR = 220; AMPERAGE ON PRIMARY = 2

40. VOLTAGE ON SECONDARY = 480 VOLTS; HOOKUP WYE-DELTA

PART E

41. A

42. 10:1

43. 100 VOLTS

44. WOUND MOTOR, INDUCTION, SYNCHRONOUS

45. A

46. A

47. A

48. C

49. VOLTAGE ON SECONDARY = 220; AMPERAGE ON PRIMARY = 1 AMP;
WATTS USED BY MOTOR = 2200; HORSEPOWER OF MOTORS = 2.9

50. A

51. B

PART E

52. S
53. P
54. P
55. S
56. P
57. P
58. S
59. P
60. S
61. B

PART G

62. L
63. A
64. B
65. D
66. C
67. E
68. H
69. K
70. F
71. J
72. G
73. M
74. I
75. P
76. O
77. N
78. Q
79. R
80. S
81. T

PART H

82. B
83. A
84. C
85. D
86. C
87. B
88. D
89. B
90. D
91. D

PART I

92. C
93. C
94. C
95. C
96. D
97. C
98. C

PART J

99. 208 VOLTS

100. 208 VOLTS

101. 208 VOLTS

102. 208 VOLTS

103. 208 VOLTS

104. 0 VOLTS, 208 VOLTS

105. 0 VOLTS, 208 VOLTS

106. 0 VOLTS, 208 VOLTS

107. "R" COIL DEFECTIVE

108. THE READINGS AT POINTS 3 AND 4. SINCE THE MOTOR RAN IN ONE DIRECTION.

109. THE NORMALLY CLOSED "F" CONTACTS MUST BE OPEN.

PART K

110. MAGNETICALLY

111. HOLDING

112. MAGNETIC FIELD

113. BLOWOUT

114. CLOSE

115. HEATER STRIPS

PART L

116. CONVEYOR MOTOR CIRCUIT

117. LEFT MAIN MOTOR

RIGHT MAIN MOTOR IS TIMED OUT BY TR1

118. "P" CONTACTS

ELECTRICAL INTERLOCK

119. RIGHT MAIN MOTOR WILL STOP, ALSO DUE TO SERIES CONNECTION OF OVERLOADS

120. MAINTAIN THE HOLDING CIRCUIT

121. INCREASE IN SPEED

122. CA CONTACTOR

123. M-2 COIL

124. NO, CIRCUIT THROUGH MOTORS NOT COMPLETE

PART M

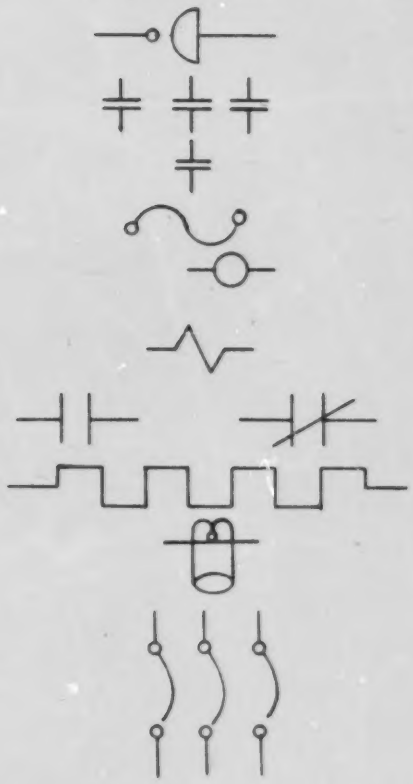
CONDITIONS FOR EXAMINATION, PART I, IDENTIFICATION.

A STUDENT WILL BE REQUIRED TO GO TO A DISPLAY TABLE ON WHICH WILL BE SEVERAL CONVENTIONAL ELECTRICAL COMPONENTS (SEE ENCLOSED LIST). HE WILL BE REQUIRED TO WRITE THE PROPER IDENTITY OF EACH PIECE AND RETURN TO HIS SEAT TO COMPLETE THE REMAINDER OF THE EXAMINATION. EACH PIECE WILL HAVE AN IDENTIFYING NUMBER ASSIGNED TO IT, AND THE STUDENT WILL BE REQUIRED TO WRITE IN THE PROPER NAME OF THE PART CORRESPONDING TO ITS NUMBER ON THE ANSWER SHEET AND DRAW IN ITS SYMBOL OPPOSITE ITS NAME.

SEE STUDENT INSTRUCTIONS.

PART M

	NAME OF PART	NAME SYMBOL
1.	MERCURY TUBE	
2.	AC CONTACTOR	
3.	DC CONTACTOR	
4.	AC HEATER	
5.	DC OPERATING COIL (OR AC)	
6.	DC OVERLOAD	
7.	AC INTERLOCK (NO) OR (NC)	
8.	SERIES STARTING RESISTOR	
9.	CURRENT TRANSFORMER	
10.	CIRCUIT BREAKER 3 Ø	



IMPLEMENTATION GUIDELINES FOR STUDENT COMPETENCY SHEETS

This section of the Guide contains 31 subsections. There is a subsection for each Student Competency Sheet in the Solid-State Curriculum. Each subsection has the following format:

1. The Unit number and title are listed.
2. Activities for conducting a pretest are listed (because pre- and posttests are the same in this program, there are no pretest activities listed).
3. Suggested instructor activities for each student Learning Activity on the Student Competency Sheet are listed.
4. Answer Sheets for Examinations and for Study Questions and Experiments are attached. Also, any outlines needed for instructor presentations are attached.

The suggested instructor activities were written under the assumption that the previous sections of this Guide would be used to determine an overall approach to implementation of a Student Competency Sheet written in a CBE format, that implementation sequences would be primarily as noted, and that hardware, power, space, equipment, and materials would be comparable to those listed.

UNIT 01: METERS, PART I

Pretest Activities

To administer a pretest you will need Student Examination #1, a Micronta Multitester, a resistor that is either "good" or "bad", and access to a circuit on which the meter can be used as an ohmmeter. Distribute the Examination, and monitor the student's performance. Check the meter settings before allowing the meter to be used on the circuit.

Instructor Activities

1. This Student Competency Sheet (SCS) can be used with an audio tape to introduce the student to the CBE format and the course materials. If you are using it this way, distribute the SCS and then have the student play the audio tape on a tape player.
2. Learning Activity (LA) #1 provides a general introduction to a VOM. To complete it the student will need Student Handout (SH) #1 and a Micronta Multitester. It is very important at this point that you establish the routine procedure of checking all responses to Study Questions immediately upon their completion. You may do this, or you may have the student do a self-check. It should be noted that the student could attain competence while using a VOM other than the Micronta. If you prefer to use a different model VOM, you will need to revise the SCS, and the next two activities accordingly.

3. LA #2 provides an introduction to the use of the Micronta Multitester as an ohmmeter. To complete it the student will need SH #2 and a Micronta Multitester. Again check responses or have students self-check responses to Study Questions immediately. It is recommended that a VOM be assigned to each student at this point.
4. LA #3 provides the student with practice using the Micronta Multitester as an ohmmeter. Have the assortment of ten resistors available. They should be of various capacities and may include both "good" and "bad" resistors.

UNIT 01: METERS, PART I

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1
CHARACTERISTICS OF THE VOM

1. Multi VOM

2. Ohms
   DC
   AC
   Decibel or battery check

3. Ohms

4. Second scale from top, or the black scale

5. Red

6. To check the battery

7. To set the meter as a volt, ohm, or ammeter

8. Off and on

9. The +DC-AC-Ohms position

10. To set the pointer at zero

11. Set the pointer to zero ohms

12. The two in the lower left corner

UNIT 01: METERS, PART I

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #2

THE OHMMETER

1.

2. An open circuit would have an INFINITE amount of resistance.

3. A battery inside the meter

4. Ohm adjustment

5. 5

6. 5,000 ohms

7. Ohms position i.e., right-hand position

8. No

9. Left

10. Reads from right to left. It is non-linear.

11. Right

12. Multiply the reading by the value for the range switch setting you are using.

ANSWER SHEET
STUDENT EXAMINATION #1

UNIT 01: METERS, PART I

1. B

2. B

3. (+DC - AC- Ω)

4. B

5. A

6. _____(TO BE COMPLETED AT TIME OF TEST)

7. _____(TO BE COMPLETED AT TIME OF TEST)

UNIT 01: METERS, PART II

Pretest Activities

To administer a pretest you will need Student Examination #1, a Micronta Multitester, and access to AC and DC circuits for purposes of voltage measurement. Distribute the Examination, and monitor the student's performance. Check the meter settings before allowing the meter to be used for reading voltages.

Instructor Activities

1. Learning Activity (LA) #1 provides the student an introduction to the use of the Micronta Multitester as an AC Voltmeter. To complete it the student will need SH #1 and the assigned Micronta Multitester. Check or have the student self-check responses to the Study Questions.
2. LA #2 provides the student with practice using the Micronta Multitester as an AC voltmeter. To complete it the student will need the AC Voltmeter Instruction Sheet, the assigned Micronta Multitester, and access to a wall receptacle, the AC belt starter panel, and the AC/ DC solid-state panel. Be sure that both panels are operating properly prior to having the student complete the voltage reading activities. Monitor performance closely, and in the case of the AC/DC panel, have the student verbally state the procedure that is to be used.
3. LA #3 provides the student with practice using the Micronta Multitester as a DC voltmeter. To complete it the student will need SH #2 and the assigned Micronta Multitester. Check or have the student self-check responses to the Study Questions.

4. LA #4 provides the student with practice using the Micronta Multitester as a DC voltmeter. You should provide at least two operative DC circuits for this purpose. The battery-powered,solid-state panel would provide one opportunity.

Unit 01: Meters, Part II

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

THE AC VOLTMETER

1. At any of the four (4) AC volts positions
2. 3 volts
3. 20 volts
4. 300 volts
5. 50 volts
6. AC 1KV
7. Largest
8. Getting shocked and shorting out close terminals

Unit 01: Meters, Part II

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #2

THE DC VOLTMETER

1. 7
2. In al' ways, except it is black
3. 3 volts
4. 1 volt
5. DC 1KV jack
6. The pointer will try to move backwards.
7. The -DC position

ANSWER SHEET

STUDENT EXAMINATION #1

UNIT 01: METERS, PART II

1. C

2. B

3. B

4. TRIES TO MOVE BACKWARD

5. 200 VOLTS

6. _____(TO BE COMPLETED AT TIME OF TEST)

7. _____(TO BE COMPLETED AT TIME OF TEST)

UNIT 01: METERS, PART III

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 provides the student with an introduction to the use of the Micronta Multitester as an ammeter. To complete it the student will need SH #1 and the assigned Micronta Multitester. Check or have the student self-check responses to the Study Questions.
2. LA #2 provides the student with practice using the Micronta Multitester as an ammeter. To complete it the student will need Experiment #1, the assigned Micronta Multitester, and the materials listed in Experiment #1. You should check the student's circuit construction before any meter checks are made. This is a good time to impress upon the student the importance of returning all materials and equipment to the proper storage areas. In this experiment you could construct the circuit required beforehand and give it to the student. If you do this, omit step 4.

Unit 01: Meters, Part III

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

THE AMMETER

1. No, because of its design
2. Because current must pass through the meter and large amounts of current would require large contacts and the size of the meter would be increased greatly
3. Range switch is set in one of four "DC AMP" positions.
4. In series
5. Current is conducted through the meter making the test probes "live".

ANSWERS FOR

EXPERIMENT #1

Unit 01: Meters, Part III

5. No.

   None.

6. Approximately 250 mA.

ANSWER SHEET

THE AMMETER

UNIT 01: METERS, PART III

1. B

2. A

3. C

4. A

5. B

UNIT 02: RESISTORS

Pretest Activities

To administer a pretest you need to have Examination #1 and a display table with components on it. The display table could have several types of resistors, diodes, SCR s, inductors, and capacitors. They should not be labeled.

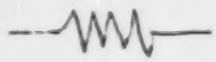
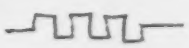
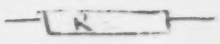
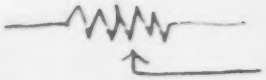
Instructor Activities

1. LA #1 familiarizes the student with the physical appearances of the various types of resistors. The display table should have wire wound and carbon resistors, potentiometers, and rheostats. At least three sizes of each should be on the table. Each component should be labeled as to type and capacity.
2. LA #2 introuduces the student to the symbols, uses, and characteristics of resistors. You need to distribute SH #1 and monitor performance. Pay particular attention that students understand the three schematic drawings included. You may want to review the names of the components used in each drawing with the students.

UNIT: 02 RESISTORS

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

RESISTORS

1. Opposition
2. Ohms
3. 
4. Watts
5. Size
6.  elementary  schematic
7. Wire wound
8. Series
9. Yes
10. 
11. Rheostat
12. Potentiometer

ANSWER SHEET

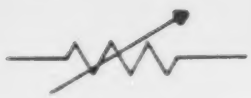
STUDENT EXAMINATION # 1

UNIT 02: RESISTORS

1. B

2.

3. B

4. 

5. B

6. A

7. A

8. B

9. A

UNIT 03: CAPACITORS, PART I

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 familiarizes the student with the physical shapes and sizes of capacitors. A total of about ten capacitors should be put on the display table. They should be various shapes, sizes, and capacities. Each capacitor should be labeled as to type, capacitance, and voltage rating.
2. LA #2 continues to familiarize the student with the physical shapes and sizes of capacitors. The student should locate a capacitor on each of the three training panels.
3. LA #3 introduces the student to capacitor symbols and size ratings. To complete it the student will need SH#1. Check or have the student self-check responses to the Study Questions.
4. LA #4 introduces the student to capacitor function. To complete it the student will need Experiment #1, the assigned Micronta Multitester, and the materials listed on Experiment #1. You should check the capacitor to make sure it is "good." A large canister-type capacitor is recommended.

5. LA #5 introduces the student to capacitor operation and procedures used to test it with a VOM. To complete it the student will need SH #2. Check or have the student self-check responses to the Study Questions.
6. LA #6 provides the student with practice in testing capacitors. To complete it the student will need Experiment #2 and the materials listed on it. You should number each capacitor and pretest it. This way you will have a check on the student's work. Be sure to include both "good" and "bad" capacitors.

UNIT 03: CAPACITORS, PART I

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1
CAPACITORS: IDENTIFICATION AND SYMBOL

1. Capacitor
2. Canister
3. ⊣(⟵
4. Capacitance
5. Micro
6. Working volts direct current
7. Bank

UNIT 03: CAPACITORS, PART I

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #2
CAPACITOR OPERATION AND TESTING

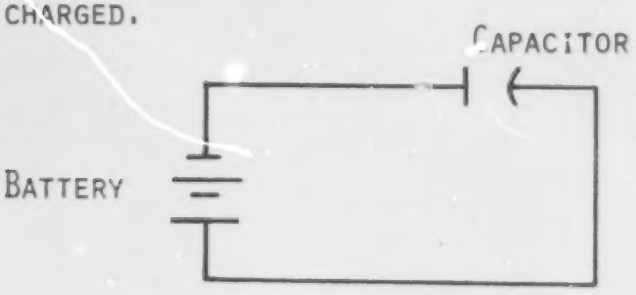
1. Insulating
2. Defective
3. Good
4. Shorted
5. None
6. Zero
7. Full
8. Full, zero

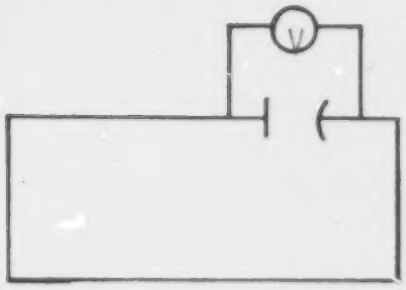
ANSWERS FOR
EXPERIMENT #1

UNIT 03: CAPACITORS, PART I

7. VOLTMETER SHOWED READING OF 6 VOLTS BECAUSE IT IS NOW CHARGED.

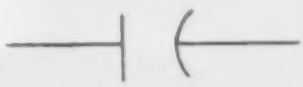
8.





ANSWER SHEET
STUDENT EXAMINATION #1

UNIT 03: CAPACITORS, PART 1

1. 

2. WORKING VOLTAGE DIRECT CURRENT

3. FARAD

4. CAPACITANCE VOLTAGE

5. BANK

6. CAPACITANCE VOLTAGE

7. STORES ELECTRICAL ENERGY OR A CHARGE

8. DEFECTIVE

9. SHORTED

10. GOOD

11. VOLTMETER

UNIT 03: CAPACITORS, PART II

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to the charging and discharging characteristics of capacitors. To complete it the student will need SH #1. Check or have the student self-check responses to the Study Questions.
2. LA #2 allows the student to observe charging and discharging characteristics of capacitors as measured on a VOM. To complete it the student will need Experiment #1 and the materials listed on it. The capacitors and resistors used should be different enough in size so that major differences in charging and discharging times can be observed. All components needed to complete this experiment may be placed on one mounting board and interconnected as necessary with wire leads.
3. LA #3 introduces the student to the major uses of capacitors. To complete it the student will need SH #2. Check or have the student self-check responses to the Study Questions.

UNIT 03: CAPACITORS, PART II

ANSWERS FOR STUDY QUESTIONS FOR STUDENT HANDOUT #1
CAPACITORS: CHARGE AND DISCHARGE TIME

1. 100 MFD
2. Circuit B
3. 5 seconds
4. Yes

UNIT 03: CAPACITORS, PART II

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #2
CAPACITORS: FUNCTION OR USE

1. Yes

2. By placing it in parallel. It will charge to full voltage, and when the supply voltage starts to decrease, it will give up its charge to the source.

3. They store electrical energy.

4. Through a suitable resistor

5. To increase the torque

ANSWER SHEET

EXAMINATION #1

UNIT 03: CAPACITORS, PART II

1. C
2. SERIES
3. CAPACITANCE
4. INCREASE
5. NO
6. IT MAY CAUSE DAMAGE TO THE METER
7. SHOCK HAZARDS

UNIT 04: INDUCTORS, PART I

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performances, and check student responses.

Instructor Activities

1. LA #1 introduces the student to basic electrical principles associated with current-carrying conductors. To complete it the student will need SH #1. Check or have the student self-check responses to the Study Questions.
2. LA #2 is optional. You should decide whether to complete it based on how well the students perform LA #1. To complete it the student will attend two demonstrations given by you. The outline for the demonstrations is attached. It also lists the materials needed for the demonstrations. If necessary, you may have individual students proceed with Part II of this Unit prior to completing the Examination. This would allow you to time the demonstrations so that at least three or four students are present.

INSTRUCTOR'S OUTLINE

LA # 2

PRIOR TO GIVING THE DEMONSTRATIONS, EXPLAIN THE FOLLOWING BASIC CONCEPTS:

1. PRODUCTION OF MAGNETIC FIELD
2. PURPOSE OF A CONDUCTOR IN A CLOSED CIRCUIT
3. RELATIVE MOVEMENT WITHIN A MAGNETIC FIELD

DEMONSTRATION I

FOLLOW THIS PROCEDURE:

1. CONNECT THE GALVANOMETER AND COIL TOGETHER.
2. MOVE THE MAGNET BACK AND FORTH THROUGH THE COIL AND HAVE STUDENTS OBSERVE THE MOVEMENT OF THE GALVANOMETER POINTER.
3. HOLD THE MAGNET STATIONARY AND MOVE THE COIL BACK AND FORTH ON THE HORSESHOE MAGNET.
4. HOLD BOTH MAGNET AND COIL STATIONARY AND OBSERVE THE POINTER ON THE GALVANOMETER.

THIS DEMONSTRATION SHOWS THE STUDENT THAT:

1. ELECTRICITY IS PRODUCED USING THIS METHOD.
2. POLARITY IS CONTINGENT ON THE DIRECTION OF THE MAGNETIC FIELD.
3. RELATIVE MOVEMENT MUST OCCUR TO PRODUCE A CURRENT.

DEMONSTRATION II

FOLLOW THIS PROCEDURE:

1. PLUG IN GROWLER TO 120 VOLTS AC.
2. CONNECT BULB ACROSS COIL.
3. TURN ON GROWLER AND SLOWLY LOWER COIL INTO GROWLER FIELD UNTIL BULB GLOWS BRIGHT. HOLD STATIONARY.
4. HOLD COIL STEADY, SWITCH OFF GROWLER. BULB WILL BRIGHTEN BEFORE GOING OUT.

THIS DEMONSTRATION SHOWS THE STUDENT:

1. MOVEMENT OF THE MAGNETIC FIELD DUE TO AC CHARACTERISTICS.
2. MAGNETIC COUPLINGS INDUCE A CURRENT IN PARALLEL WINDINGS.
3. WHEN A MAGNETIC FIELD COLLAPSES, A HIGHER VOLTAGE THAN SOURCE VOLTAGE IS PRODUCED.

UNIT 04: INDUCTORS, PART I

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

A REVIEW OF BASIS PRINCIPLES

1. Proportional
2. XL, CEMF
3. A certain amount of inductance
4. Current stops, magnetic field moves in opposite direction of original magnetic field

ANSWER SHEET
EXAMINATION #1
A REVIEW OF BASIC PRINCIPLES

1. MAGNETIC FIELD
2. THE MAGNETIC FIELD COLLAPSES
3. SAME DIRECTION
4. MAGNETISM
5. INDUCTOR
6. XL
7. MOTORS, TRANSFORMERS

UNIT 04: INDUCTORS, PART II

Pretest Activities

To administer a pretest you need to have Examination #1 and a display table with components on it. The display table could have several types of resistors, diodes, SCR s, inductors, and capacitors. They should not be labeled.

Instructor Activities

1. LA #1 introduces the student to function, identification, a id symbol of inductors. To complete it the student will need SH #1. Check or have the student self-check responses to the Study Questions.

UNIT 04: INDUCTORS, PART II

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

FUNCTION, IDENTIFICATION, AND SYMBOL OF INDUCTORS

1. Provide inductance in a circuit
2. Size is proportional to capacity
3.
4. Acts like a transformer to assist source voltage

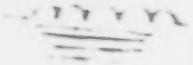
   Acts like a resistance to oppose source voltage

   Acts like a capacitor and discharges during collapse

ANSWER SHEET

EXAMINATION # 1

UNIT 04: INDUCTERS, PART II

1. 

2. INDUCTANCE INCREASES

3. TO PROVIDE A SPECIFIC AMOUNT OF INDUCTANCE

4. CEMF PRODUCED, OPPOSING MAGNETIC FIELD PRODUCED

5. WHEN THE MAGNETIC FIELD COLLAPSES

UNIT 04: INDUCTORS , PART III

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to inductor operation. To complete it the student will need SH #1. Check or have the student self-check responses to the Study Questions.
2. LA #2 allows the student to observe operation of an inductor through the use of meter readings and other components. To complete it the student will need Experiment #1 and the materials listed on it. Monitor performance closely because it is easy to burn out the inductor by exceeding voltage levels. You should check the circuit board to ensure that all components are functioning properly before having the student begin work.

UNIT 04: INDUCTORS, PART III

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #3
INDUCTOR OPERATION

1. Inductive reactance is produced.

2. B

3. Resistance is created.

4. D

5. Magnetic field collapses.

6. B

7. Check with an ohmmeter.

ANSWERS FOR
EXPERIMENT #1

UNIT 04: INDUCTORS, PART III

8. BULB GLOWS WHEN INDUCTOR IS CONNECTED IN CIRCUIT DUE TO INDUCTIVE KICK.
9. EXPLANATION SHOULD AT LEAST INCLUDE THE CONCEPT THAT AN INDUCTOR IN THE CIRCUIT INCREASES INDUCED VOLTAGE AND THE HIGHER INDUCED VOLTAGE CAN BE USED TO OVERCOME RESISTANCE.

ANSWER SHEET
STUDENT EXAMINATION #1
INDUCTOR OPERATION

UNIT 04: INDUCTERS, PART III

1. B
2. INDUCTIVE REACTANCE (CEMF)
3. INDUCTOR BUILDS UP OWN VOLTAGE WHICH OPPOSES ORIGINAL CURRENT.
4. INDUCED VOLTAGE FROM THE INDUCTOR
5. YES
6. AN OHMMETER

UNIT 05: DIODES, PART I

Pretest Activities

To administer a pretest you need to have Examination #1 and a display table with components on it. The display table could have several types of resistors, diodes, SCR s, inductors, and capacitors. They should not be labeled.

Instructor Activities

1. LA #1 familiarizes the student with the physical shape and size of diodes. Ten diodes would be sufficient for the display. Make sure they are different sizes. Also, include SCR s on the table. Label each component.
2. LA #2 introduces the student to various major functions of a diode. To complete it the student will need SH #1. Check or have the student self-check responses to the Study Questions.
3. LA #3 gives the student practice in testing diodes. To complete it the student will need Experiment #1, the assigned Micronta Multitester, and five diodes. You should include both "good" and "bad" diodes. If you pretest the diodes before giving them to the student, you will have an easy way to check the student's work.

UNIT 05: DIODES, PART I

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1
DIODES: IDENTIFICATION AND FUNCTION

1.

   Cathode Anode

2. False

3. All of them

4. False

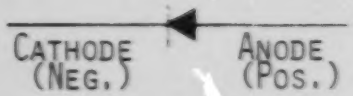
5. B

6. C

7. Zener diode

ANSWERS FOR
EXPERIMENT #1

UNIT 05: DIODES, PART I

1. 

2. DETERMINED AT TIME OF EXPERIMENT.

3. B

4. C

ANSWER SHEET

STUDENT EXAMINATION

UNIT 05: DIODES, PART I

1. B
2. C
3. B
4. HEAT SINK
5. A
6. A
7. B
8. D
9. No

UNIT 05: DIODES, PART II

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to the major uses of diodes. To complete it the student will need SH #1.
2. LA #2 provides the student with practice in using diodes in rectifiers. To complete it the student will need Experiment #1 and the materials listed on it. It is recommended that the rectifiers be constructed for the student. In either case you should check the operation of the circuits before having the student take any meter readings.

ANSWERS FOR
EXPERIMENT #1

UNIT 05: DIODES, PART II

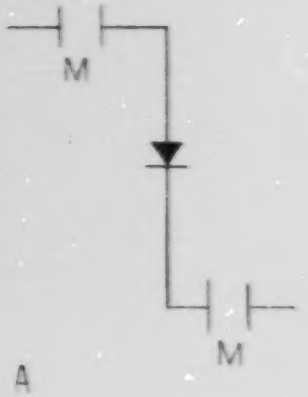
2.C. YES, BECAUSE HALF-WAVE RECTIFICATION USES ONLY ONE-HALF OF THE AC SINE WAVE. CURRENT FLOWS TO THE LAMP ONLY ONE-HALF THE TIME.

3.C. YES, BECAUSE THERE IS A SLIGHT VOLTAGE DROP ACROSS THE RECTIFIER JUST AS IN ANY TRANSFORMER.

3.D. YES, BECAUSE CURRENT FLOWS TO THE LAMP AT ALL TIMES. THE FULL AC SINE WAVE IS USED.

ANSWER SHEET
STUDENT EXAMINATION

UNITOS: DIODES, PART II

1. 

A

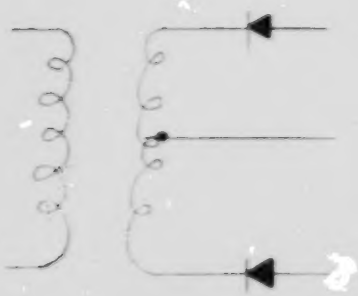
B. YES

2. FALSE

3. HALF-WAVE

4. B

5. A. 2

B. 

UNIT 06: SCR, IDENTIFICATION AND SYMBOL

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 familiarizes the student with the physical shape and size of SCRs. Ten SCRs will be needed to set up the table. Make sure that various sizes are used. Each component should be labeled as to type and capacity.
2. LA #2 introduces the student to the characteristics of the SCR and its symbol. To complete it the student needs SH #1.

ANSWER SHEET

STUDENT EXAMINATION #1

UNIT 06: SCR IDENTIFICATION AND SYMBOL

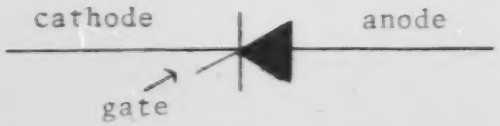
1. AN SCR HAS AN ADDITIONAL LEAD

2. SYMBOL

3. B

4. CATHODE, ANODE, GATE

5. CATHODE

6. 

UNIT 06: SCR, OPERATION

Pretest Activities

To administer a pretest distribute Examination #2, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to the way the SCR operates when it is on. To complete it the student needs SH #2. Check or have the student self-check responses to the Study Questions.
2. LA #2 introduces the student to the way the SCR functions when it is off. To complete it the student needs SH #3. Check or have the student self-check responses to the Study Questions.
3. LA #3 lets the student observe the operation of an SCR through meter readings and functions of other components. To complete it the student needs Experiment #1 and the materials listed on it. It is recommended that the circuits be constructed ahead of time and given to the student. In either case you should check the operation of the circuit before having the student begin work. Do not use an SCR with a sensitive gate for this experiment.

UNIT 06: SCR, OPERATION

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #2
SCR OPERATION - ON

1. It is on, allowing current to flow in one direction.

2. A. -

   B. +

   C. +

3. A. Interrupt current flow

   B. Decrease current flow to a very low level

4. The least amount of current necessary to hold an SCR in conduction or on

UNIT 06: SCR, OPERATION

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #3
SCR OPERATION - OFF

1. A

2. B

3. Because the reversed voltage produced by the capacitor connected across the SCR is higher than the SCR voltage.

4. No, the capacitor must have the same capacitance and voltage rating as the SCR or a higher rating.

ANSWERS FOR
EXPERIMENT #1

UNIT 06: SCR, OPERATION

5. YES.
6. SCR REMAINS IN CONDUCTION WITH DC POWER SUPPLY UNTIL HOLDING CURRENT IS INTERRUPTED.
7. THE ONLY REASON THE LIGHT WOULD NOT STAY ON IS THAT SOME CONDITION WOULD INTERRUPT THE HOLDING CURRENT TO THE GATE OF THE SCR.
9. WITH AN AC POWER SUPPLY THE LIGHT WOULD GO OUT WHEN THE SWITCH IS OPENED. THIS IS DUE TO THE ALTERNATING NATURE OF AC. WHEN DIRECTION IS CHANGED THE HOLDING CURRENT IS INTERRUPTED AND THE SCR IS "OFF".

ANSWER SHEET

STUDENT EXAMINATION #2

UNIT 06: SCR, OPERATION

1. B
2. B
3. A
4. B
5. B

UNIT 06: SCR, VOLTAGE CONTROL

Pretest Activities

To administer a pretest distribute Examination #3, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to the function and use of the SCR for voltage control. To complete it the student needs SH #4. You need to monitor the use of SH #4 closely. It is the most technical SH so far in this program. Provide the student with assistance in understanding the schematic drawings and the graphs.

ANSWER SHEET
STUDENT EXAMINATION #3

UNIT 06: SCR: VOLTAGE CONTROL

1. NO, BECAUSE SCR WILL BE OFF ONE-HALF OF THE TIME AND BLOCK THE AC.

2. A, BECAUSE SCR'S USE ALL OF THE SINE WAVE.

3. A, BECAUSE SCR IS "OFF" LONGER THAN IN A; OR SCR IS "ON" LONGER IN B.

UNIT 07: TRIGGERING CIRCUITS

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to resistance triggering and the way a resistance triggering circuit operates. To complete it the student will need SH #1, the seven visuals that accompany SH #1, Experiment #1, and the materials listed on it. Be sure to check the operation of the circuit in Experiment #1 before letting the student work with it.
2. LA #2 introduces the student to RC triggering and how an RC trigger circuit operates. To complete it the student will need SH #2, the two visuals that accompany SH #2, Experiment #2, and the materials listed on it. Be sure to check the operation of the circuit in Experiment #2 before letting the student work with it.
3. LA #3 introduces the student to UJT triggering and the way a UJT trigger circuit operates. To complete it the student will need SH #3, the one visual that accompanies SH #3, Experiment #3, and the materials listed on it. Be sure to check the operation of the circuit in Experiment #3 before letting the student work with it.

4. Due to the technical nature of the content of this unit, some students may benefit more from instructor presentations than they will from the handouts. If you judge this to be the case, use the handouts as outlines, and prepare and give a presentation from each.

ANSWERS FOR
EXPERIMENT #1

UNIT 07: TRIGGERING CIRCUITS

1. DOES NOT LIGHT BECAUSE GATE CIRCUIT IS OPEN.

2.A. LIGHT COMES ON BECAUSE GATE CIRCUIT IS CLOSED.

2.B. LIGHT STAYS ON BECAUSE GATE CIRCUIT HOLDS SCR IN CONDUCTION.

2.C. LIGHT CONTINUES TO BURN AND DOES NOT INCREASE OR DECREASE IN BRIGHTNESS BECAUSE THE VOLTAGE AT WHICH THE SCR IS TURNED "ON" IS THE VOLTAGE AT WHICH IT OPERATES UNTIL IT IS TURNED "OFF" AND TURNED "ON" AGAIN AT A DIFFERENT VOLTAGE.

3. YES, LIGHT GOES OUT WHEN S_2 IS OPENED.

4. NOTHING HAPPENS TO BRIGHTNESS OF LAMP IN A DC CIRCUIT. IN AN AC CIRCUIT THE BULB WILL BURN BRIGHTER.

5. NOTHING HAPPENS TO BRIGHTNESS OF LAMP IN A DC CIRCUIT. IN AN AC CIRCUIT THE BULB WILL DIM OR GO OUT.

6. SCR WILL CONTINUE TO CONDUCT IN A DC CIRCUIT. IN AN AC CIRCUIT THE SCR WILL SWITCH "OFF".

ANSWERS FOR
EXPERIMENT #2

UNIT 07: TRIGGERING CIRCUITS

4. GOES OFF.
5. DETERMINED AT TIME OF EXPERIMENT. APPROXIMATELY 3 VOLTS.
6. HIGHER READING.
8. IT IS DIMMER.

ANSWERS FOR
EXPERIMENT #3

UNIT 07: TRIGGERING CIRCUITS

2. GOES OFF AND ON.
3. MEASUREMENTS SHOULD DECREASE AS POTENTIOMETER SETTING INCREASES.
4. TO PROVIDE TRIGGERING PULSE FOR SCR.
5. BY VOLTAGE LEVEL NEEDED TO OPERATE UJT.
6. PROVIDES A WIDER RANGE OF CONTROL.
7. MORE CONTROL.
   TRIGGER PULSE LEVEL CAN BE QUITE LOW.

STUDENT EXAMINATION #1
ANSWER SHEET

UNIT 07: TRIGGERING CIRCUIT

1. A
2. A
3. A
4. B
5. A
6. C
7. C
8. C

UNIT 08: SCHEMATICS: DC SYMBOLS

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to common DC symbols used on electrical prints. This should be a review for most students. To complete it the student will need SH #1. Check or have the student self-check the responses to the items on Study Sheet #1.
2. LA #2 gives the student practice in drawing and naming DC symbols. You need to provide 3" x 5" or 4" x 8" index cards for the student to use. You should check the students' cards for accuracy before letting them proceed to LA #3.
3. LA #3 gives the student practice in recognizing and naming DC symbols. Students should practice together until they are ready for the Examination.

UNIT 08: SCHEMATICS: DC SYMBOLS

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

DC SYMBOLS

1. OFF Button

2. In its natural relaxed state, it is open.

3. normally closed, instant opening

normally open, time-delay closing

normally open, instant closing

normally open, time-delay closing and opening

normally closed, time-delay closing and opening

4. or , any # letter, A, 4A

5. A

6. Operating circuit

7. Forward contact coil for motor b

8. Motor C, shunt field wire #2, series field wire #2

9. R-1

10. Resistor, coil, contactor

ANSWER SHEET

STUDENT EXAMINATION #1

UNIT 08: SCHEMATICS: DC SYMBOLS

1. RESISTORS, COILS, AND CONTACTORS

2. A.

   B. P1

   C. P1

3.

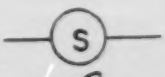
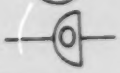
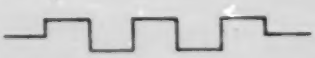
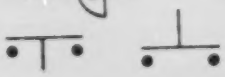
4. C

5. R-1

6.

OPERATING CIRCUIT	POWER CIRCUIT
A. COIL	A. CONTACTOR
B. MERCURY SWITCH	B. RESISTOR
C. PUSH BUTTON (STOP OR START)	C. MOTOR
D. FUSE	

7.

OPERATING CIRCUIT	POWER CIRCUIT
A. 	A.
B. 	B. 
C. 	C.
D.	

UNIT 08: SCHEMATICS: DC CIRCUIT TRACING

Pretest Activities

To administer a pretest give the student five copies of the DC print. Have the student use a pencil to trace current flow on the prints for starting, slow speed operation, and fast speed operation. Three copies are used to explain starting procedures. Also, have the student explain the operation of the DC circuit.

Instructor Activities

1. LA #1 introduces the student to the components used on the DC circuit print. To complete it the student will need SH #1 and a copy of the DC print.
2. LA #2 introduces the student to the sequence of operation of the components used on the DC circuit print. To complete it the student will need SH #2 and a copy of the five DC prints (Steps 1 through 5).
3. LA #3 allows the student to practice circuit tracing for the DC circuit print. This is for starting procedures. You need to provide a clean copy of the DC print, Check the student's work, and have any errors corrected.
4. LA #4 allows the student to practice circuit tracing for the DC print for slow speed operations. You need to provide a clean copy of the DC print. Check the student's work, and have any errors corrected.
5. LA #5 allows the student to practice circuit tracing for the DC print for fast speed operations. You need to provide a clean copy of the DC print. Check the student's work, and have any errors corrected.

6. LA #6 allows the student practice in explaining the sequence of operations of components in a DC circuit. The students should practice until they are ready to take the Examination.

UNIT 09: SCHEMATICS: AC SYMBOLS

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

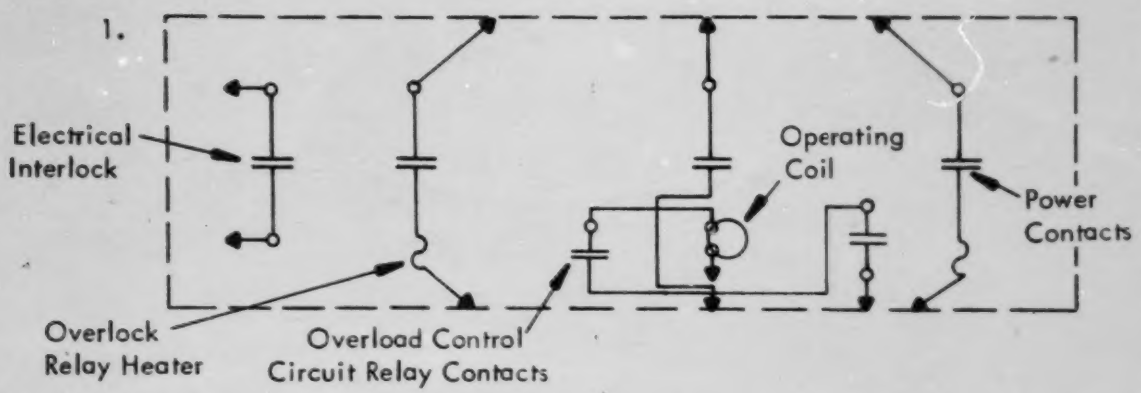
1. LA# 1 introduces the student to symbols used for common AC components on electrical prints. To complete it the student will need SH #1. Check or have the student self-check responses to the items on Study Sheet #1.
2. LA #2 gives the student practice in drawing the symbols for and naming common AC components. You need to provide the student with either 3" x 5" or 4" x 8" index cards. Check the student's work before letting them proceed to LA #3.
3. LA #3 gives the student practice in recognizing and naming symbols for common AC components. The students should practice until they are ready to take the Examination.

UNIT 09: SCHEMATICS: AC SYMBOLS

ANSWERS TO STUDY QUESTIONS FOR STUDENT HANDOUT #1

AC SYMBOLS

1.

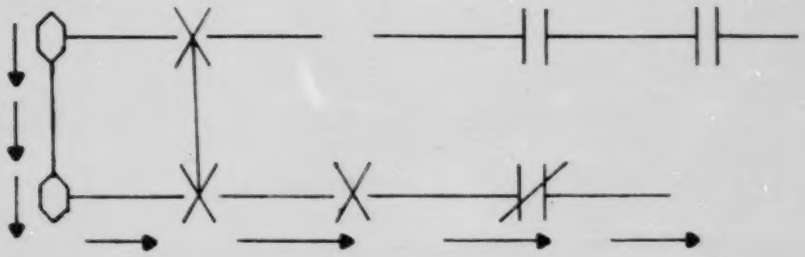


2. 3

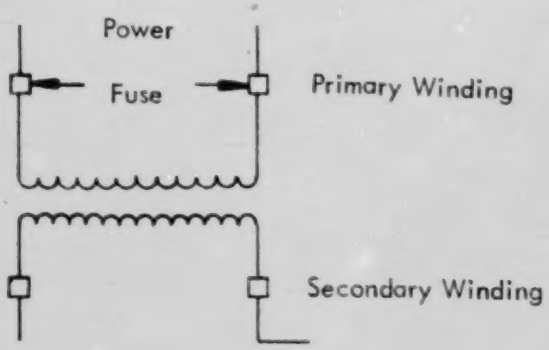
3. D

4. No

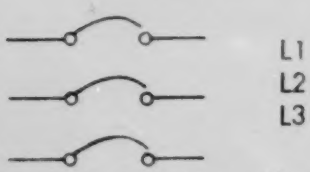
5.



6.



7.

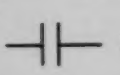


8. If unsafe quantities of methane are detected through the detector head, the normally closed switch opens and cuts power to the machine.

ANSWER SHEET

STUDENT EXAMINATION #1

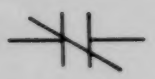
UNIT 09: SCHEMATICS: AC SYMBOLS

1. A. 

   B.

   C.

   D.

   E. 

2. 3

3. 3 SETS

4. SWITCH CLOSED IN THAT POSITION

5. A. OVERLOAD LEFT MAIN MOTOR

   B. OPERATING COIL FOR P CONTACTS

   C. OPERATING COIL FOR TIMED RELAY

UNIT 09: SCHEMATICS: AC CIRCUIT TRACING

Pretest Activities

To administer a pretest provide the student with four copies of the AC print. Have the student use a pencil to trace the current flow on the copies of the print for pump motor starting, the holding circuit for pump motor, left main motor start-up, and right main motor start-up. Also have the student explain the operation of the components in the circuit for each procedure for which current flow is traced.

Instructor Activities

1. LA #1 introduces the student to the operating sequence of the components on the AC print. To complete it the student will need to have SH #1.
2. LA #2 gives the student practice in tracing AC circuits. You need to provide the student with four clean copies of the AC print. Check the student's work after each operation is traced on a copy of the print. Have any errors corrected.
3. LA #3 gives the student practice in explaining sequences of operation on AC prints. Print copies from LA #2 may be used here. The students should practice until they are ready for the Examination.

UNIT 10: SCHEMATICS: AC/DC SOLID-STATE

Pretest Activities

To administer a pretest provide the student with Diagrams 1, 2, and 3 which are used as the AC/DC solid-state print. Have the student use a pencil to trace pulse flow on the prints. Also, have the student explain the operating sequences that are traced.

Instructor Activities

1. LA #1 introduces the student to the AC/DC solid-state prints and training panel. To complete it you will give the student a presentation. To give the presentation you will need the Instructor's Outline(attached), WD 3536-36 from Joy Manufacturing, and the AC/DC solid-state training panel.
2. LA #2 introduces the student to the sequence of operations for the AC/DC solid-state circuits. To complete it, the student will need SH#1. This is an extremely lengthy and complex SH. You should expect to supplement it with explanations, discussions, and demonstrations on the AC/DC solid-state training panel.
3. LA #3 gives the student practice in tracing the pulse through an AC/DC solid-state system. You need to provide the student with clean copies of the AC/DC solid-state print. You should check the student's work after each operational sequence is traced. Have any errors corrected.
4. LA #4 gives the student practice in explaining the operational sequences involved with the AC/DC solid-state print. The copies of the print from LA #3 should be used here.

5. LA #5 checks the student's understanding of the operation of the AC/DC solid-state system. To complete it the student will need a copy of the Study Questions.

INSTRUCTOR'S OUTLINE FOR LA #1

IDENTIFICATION:

1. IDENTIFY EACH SYMBOL.
2. EXPLAIN EACH SYMBOL (WHERE NECESSARY).
3. RELATE POWER AND CONTROL CIRCUIT SYMBOLS.

OPERATION:

1. CONTROL TRANSFORMER
   - A. POWER SOURCE
   - B. VOLTAGE
2. CONTROL SWITCH
   - A. POSITIONS
   - B. PURPOSE
3. PUMP AND TRACTION SWITCH
   - A. POSITIONS
   - B. HOLDING CIRCUIT
4. CUTTER MOTOR SWITCH
   - A. POSITIONS
   - B. HOLDING CIRCUIT

AFTER ALL SWITCH OPERATIONS AND POSITIONS ARE EXPLAINED, CONFINE TRACING, CURRENT FLOW, AND CIRCUIT OPERATION TO:

A. PUMP AND TRACTION CIRCUIT
   1. SWITCH POSITIONS
      - A. START CIRCUIT
      - B. HOLDING CIRCUIT

B. Tram Levers, Switch Positions
    A. Interlocks
    B. Safety

C. Left Traction Motor Operation
    1. Current flow through circuit
        A. DM switch
        B. Low speed
    C   C. High Speed

D. Cutter Motor Circuit
    1. Cutter motors running
        A. Slow speed
        B. Current flow

E. Logic Box
    1. Terminal markings
        A. Left motor
        B. Right motor

F. Firing Package
    1. Terminal markings
        A. Left motor
        B. Right motor
        C. Relate to Logic Box

ANSWER SHEET

STUDENT QUESTIONS

TRACING PULSE, AC/DC SOLID-STATE PANEL

UNIT 10: SCHEMATICS: AC/DC SOLID-STATE

1.

2. HOLDING CIRCUIT

3. PUMP MOTOR COULD NOT START.

4. CLOSED

5. (A) CONNECTS PUMP MOTOR TO LINE VOLTAGE
(B) CONNECTS PRIMARY OF POWER TRANSFORMER TO LINE VOLTAGE

6. DOL AND TOL

7. DEADMAN SWITCH, FUNCTION BLOCK, BOTH D1 60 AND 160, DR SWITCH, D1 INTERLOCK, D1 COIL

8. D1 CONTACTORS, TRANSFORMER SECONDARY, DELTA CONFIGURATION

9. TRAM LEVER, FUNCTION BLOCK, eFR SWITCH, eFR INTERLOCK, E FOR, COIL L1R COIL, L1R CONTACT (AT POINT 40), L1R RELAY

10.

11. FORWARD CONTACTORS OF THE LEFT-HAND MOTOR

12. L2R COIL, L2R RELAY

13. THE MACHINE WOULD STAY IN SLOW SPEED.

14.

15. TRAM SWITCH, eFR SWITCH, E REV, INTERLOCK, E FOR, COIL, DEADMAN SWITCH, FUNCTION BLOCK, CMR RELAY, HSR RELAY, SR SWITCH, D1 INTERLOCK, S1 COIL, OLR1, L1R COIL, L1R RELAY, eFR CONTACT, CMR RELAY, L2R COIL, L2R RELAY

16. YES, L2R IS STILL CLOSED.

UNIT 11: CIRCUIT CONNECTIONS: AC/DC SOLID-STATE

Pretest Activities

To administer a pretest provide the student with the assigned Micronta Multitester, hand tools, prints for the AC/ DC solid-state training panel (either copies of Diagrams 1, 2, and 3 from Unit 10 or WD 3536-36 from Joy Manufacturing), and replacement solid-state components if available. Have the AC/DC solid-state panel in this condition: (1) logic box removed, (2) SCR bridge disconnected, and (3) firing package in place. Have the student install the logic box, connect the SCR bridge, and remove and replace the firing package.

Instructor Activities

1. LA #1 introduces the student to the connections and functions of the main solid-state devices on the AC/DC solid-state training panel. To complete it the student will need SH #1, prints for the AC/DC solid-state training panel (either Diagrams 1,2, and 3 from Unit 10 or WD 3536-36 from Joy Manufacturing), and access to the AC/DC solid-state training panel. Check or have the student self-check responses to the items on SH #1.
2. LA #2 introduces the student to the main interconnections on the AC/DC solid-state training panel. To complete it the student will need SH#2, prints for the AC/DC solid-state training panels (either Diagrams 1,2, and 3 from Unit 10 or WD 3536-36 from Joy Manufacturing), and access to the AC/DC solid-state training panel. Check or have the student self-check responses to the items on SH #2.

3. LA #3 gives the student practice in interconnecting the main solid-state devices on the AC/DC solid-state training panel. To complete it the student will need SH #3, the assigned Micronta Multitester, hand tools, AC/DC solid-state prints (either Diagrams 1,2, and 3 from Unit 10 or WD 3536-36 from Joy Manufacturing), and access to the AC/DC solid-state training panel. You should check the student at the following points in each of the four major procedures: (1) the initial set of meter readings, (2) all connections after the device has been removed and replaced, (3) the time while the student energizes the panel, and (4) the final set of meter readings.

UNIT 11: CIRCUIT CONNECTIONS: AC/DC SOLID-STATE

ANSWERS TO QUESTIONS ON STUDENT HANDOUT #1

KNOW THE PANEL

1. A. 19

   B. Color coded and number tags

   C. On the left side (numbers 1-6)

   D.

   E. Logic box, bridge SCRs, bridge transformer

2. A. 24

   B. Opinion

   C. Plugs instead of screw terminals

3. A. Ohmmeter

   B. Bridge transformer, firing package, motor contactors

   C. Opinion

UNIT 11: CIRCUIT CONNECTIONS: AC/DC SOLID-STATE

ANSWERS TO QUESTIONS FOR STUDENT HANDOUT #2

KNOW THE INTERCONNECTIONS

1. A. Control circuit power on "F" reversing coil

   B. NO contacts on "D" line starter

   C. Deadman Switch

   D. #13 on firing package

   E. NO contacts on "B" contactor

   F. #2 terminal on pump and traction switch

   G. #6 on right traction switch

   H. #3 on right traction switch

   I. #5 on left traction switch

   J. #6 on left traction switch

2. A. Primary on bridge transformer

   B. Primary on bridge transformer

   C. Primary on bridge transformer

   D. NO contacts on "D" contactor

   E. Logic box terminal #62

   F. Logic box terminal #63

   G. Nothing

   H. Logic box terminal #162

   I. Logic box terminal #160

   J. Gate of SCR in left bridge

3. A. #5 Terminal on firing package

   B. #3 Terminal on firing package

   C. White lead

UNIT 12: CONTROL POSITIONS AND TERMINAL VOLTAGES

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 lets the student review the operation of AC/DC solid-state circuits. SH#1 from Unit 10 should be used. The students can use the copy they used in Unit 10, or you can provide them with new copies.
2. LA#2 introduces the student to control positions and terminal voltage points on the AC/DC solid-state system. To complete it the student needs the four diagrams that accompany SH#1.
3. LA#3 provides the student with further information on the control positions and terminal voltage points on the AC/DC solid-state system. To complete it the student will need SH#1 from LA#2.
4. LA#4 lets the student identify control positions and terminal voltage points on the AC/DC solid-state system. You need to ensure that the student has access to the AC/DC solid-state training panel.

ANSWER SHEET

EXAMINATION #1

UNIT 12: CONTROL POSITIONS AND TERMINAL VOLTAGES

1. (A) 1CB

   (B) LINE VOLTAGE

   (C) DIAGRAM #3; 1CB

2. (FOOTSWITCH OR DEADMAN) DIAGRAM #2

3. DIAGRAM #1; 6CB, CONTROL SWITCH, PUMP AND TRACTION SWITCH AND DIAGRAM #3; 2CB

4. (1) 1CB - CLOSED

   (2) 2CB - CLOSED

   (3) 6CB - CLOSED

   (4) CONTROL SWITCH - RUN

   (5) PUMP AND TRACTION SWITCH - RUN

   (6) FOOTSWITCH OR DEADMAN - CLOSED

   (7) LEFT-HAND TRACTION SWITCH - SLOW (FORWARD OR REVERSE)

5. 3CB OR BRIDGE BREAKER (DIAGRAM #4)

6. 1 AND 2, 3 AND 4, 5 AND 6 OR 19 AND 20, 21 AND 22, 23 AND 24.

7. PUMP AND TRACTION SWITCH - FAST POSITION

   TRACTION SWITCH - FAST POSITION

UNIT 13: TROUBLESHOOTING: OPERATOR'S REMARKS

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses.

Instructor Activities

1. LA #1 introduces the student to information that can be gained by listening to an operator. To complete it the student needs SH #1. You need to check the responses to the items on the handout. There is more than one acceptable response to each item.
2. LA #2 familiarizes the student with the process of asking questions of mine machine operators. To complete it the student needs SH #2. You need to check the responses to the items on the handout. There is more than one acceptable response to each item.
3. LA #3 provides students with practice in interpreting operator's remarks. To complete it the student needs SH #3. You need to assign students so they work in teams. Responses to each group of items on the handout should be checked. There is more than one acceptable response to each item.

UNIT 14: TROUBLESHOOTING: AC/DC SOLID-STATE

Pretest Activities

To administer a pretest you need to use the AC/DC solid-state training panel. It is recommended that you present the student with four different troubleshooting situations. The situations may be the same as those presented in the problems in the Learning Activities, or they may be equivalent. In either case you need to induce each situation in the training panel. The student will need the following to complete the pretest: the assigned Micronta Multitester, hand tools, Specification Chart, Troubleshooting Guide, and AC/DC solid-state prints (either Diagrams 1, 2, and 3 from Unit 10 or WD 3536-36 from Joy Manufacturing).

Instructor Activities

1. LA#1 allows the student to review AC/DC solid-state circuit operations. SH#1 from Unit 10 should be available to the student.
2. LA#2 introduces the student to exact meter readings associated with the AC/DC solid-state training panel. To complete it the student will need the Specification Chart. Check or have the student self-check responses to the problems at the end of the Specification Chart.
3. LA#3 introduces the student to troubleshooting procedures associated with the AC/DC solid-state training panel. To complete it the student will need the Troubleshooting Guide. Check or have the student self-check responses to the problems at the end of the Troubleshooting Guide.
4. LA#4 allows the student to troubleshoot a problem on the AC/DC solid-state training panel. You need to select the problem and create the situation in the training panel. To complete the problem the student will need a Troubleshooting Problem, Troubleshooting Guide, Specification Chart, the assigned

Micronta Multitester, hand tools, and AC/DC solid-state prints (either Diagrams 1,2, and 3 from Unit 10 or WD 3536-36 from Joy Manufacturing).

5. LA#5 allows the student to practice troubleshooting the AC/DC solid-state training panel. For each Troubleshooting Problem proceed as described in #4 above.

ANSWER SHEET
TROUBLESHOOTING PROBLEMS #1-#8

UNIT 14: TROUBLESHOOTING, AC/DC SOLID-STATE

PROBLEM #1.

(A) ZERO VOLTS

(B) 120 VOLTS AC

(C) #8 AND #2

(D) CONNECTING WIRE BETWEEN POINT #2 OF PUMP AND TRACTION SWITCH IS OPEN; REPLACE WIRE, OR REPAIR.

(H) 120 VOLTS AC

STUDENT MUST HAVE CLOSED ALL REQUIRED SWITCHES TO OBTAIN PROPER READINGS.

WHEN ZERO VOLTS WERE READ BETWEEN POINT #8 AND #2, HE SHOULD HAVE IMMEDIATELY KNOWN TO PROCEED TOWARD THE NEXT POINT, TOWARD THE VOLTAGE SOURCE WHICH WOULD BE PUMP INTERLOCK TO LOGIC BOX.

PROBLEM #2.

(A) VOLTAGE IS 120 VOLTS AT INPUT.

(B) FOOTSWITCH TRAVEL TOO SHORT, NO INPUT TO POINT #30 OF LOGIC BOX.

(C) ADJUST FOOTSWITCH TRAVEL.

STUDENT SHOULD HAVE CLOSED ALL REQUIRED SWITCHES TO OBTAIN PROPER READINGS. PROPER VOLTAGES WOULD APPEAR BETWEEN:

(1) POINT #8 AND #2

SECOND POINT HE SHOULD HAVE CHECKED:

(2) #33 TO #2, NO VOLTAGE

IF THE FOOTSWITCH WAS NOT ADJUSTED, THE STUDENT MIGHT DIAGNOSE THE PROBLEM AS A DEFECTIVE LOGIC BOX

PROBLEM #3

SHORTED CIRCUIT: A JUMPER WIRE HAS BEEN ATTACHED TO THE E FORWARD COIL FROM THE HOT SIDE OF THE PUMP AND TRACTION SWITCH. STUDENT SHOULD TAKE A VOLTAGE READING ACROSS E FOR. COIL AND GET A ZERO READING UNDER NORMAL CONDITIONS.

HE SHOULD DETERMINE THAT THE SWITCH IS DEFECTIVE OR A STRAY WIRE HAS ENERGIZED THE COIL. ALSO, BY CHECKING HIS DIAGRAM, HE CAN READILY DISCOVER THAT THERE IS AN EXTRA WIRE WHERE NONE BELONGS.

(1) POINT #16 TO #2

(2) POINT #11 TO #2

PROBLEM #4

SHORTED DIODES IN BRIDGE: TWO BRIDGE DIODES HAVE BEEN JUMPERED ACROSS (HAVING NO MOTORS AND LOAD, THIS AMOUNTS TO SHORTING OUT TWO PHASES, SIMULATING A SHORTED DIODE). THE OHMMETER READINGS REQUIRED HERE WOULD ACTUALLY INDICATE A SHORTED DIODE IN THE BRIDGE CIRCUIT.

(A) SHORTED SCR BRIDGE AND/OR DIODES.

(B) REPLACE SHORTED COMPONENT OR SCR UNIT.

PROBLEM #5

PROBLEM: CONNECTING WIRES FROM POINTS 1 THROUGH 6 ARE LOOSE AT THE SCR BRIDGE (DUMMY WIRES OR TERMINALS INSULATED).

(A) SINCE ONLY THE LEFT HAND MOTOR HAS A PROBLEM, THE STUDENT SHOULD GO TO THE FIRING PACKAGE FIRST, POINTS 1-6 AND CHECK FOR A SIGNAL.

(B) THE SIGNAL WILL BE OK, THEREFORE, ONE OF FIVE THINGS CAN BE WRONG.

(1) LEADS GOING TO SCR BRIDGE OPEN

(2) THE BRIDGE ITSELF IS OPEN; DIODES AND/OR SCR

(3) THE DC WIRING FROM THE BRIDGE TO THE MOTOR

(4) AC WIRING TO THE LEFT HAND BRIDGE

(5) THE MOTOR ITSELF

PROBLEM #6

A JUMPER WIRE HAS BEEN CONNECTED TO POINT #10 OF THE LOGIC BOX FROM POINT #8. THE LOGIC BOX BEING OUT OF SEQUENCE (DEADMAN OPEN) THE D1 OR S1 WILL NOT PICK UP.

THIS WOULD SIMULATE A FAULTY TRAM SWITCH (SHORTED).

STUDENT SHOULD HAVE CHECKED VOLTAGE READINGS FROM POINT #8 TO #2 WITH THE TRAM SWITCH OFF AND READ ZERO: HE WILL ACTUALLY READ 120 V AC WITH THE TRAM LEVER OFF. (ALSO THE INPUT LIGHT WILL BE ON.)

PROBLEM #7

THE PROBLEM IS THAT EOL AND FOL HAVE BEEN CLOSED (JUMPER WIRE). THIS WILL ACTIVATE OLR1 IN THE LOGIC BOX AND A READING WILL BE OBTAINED AT POINTS 68 AND 69 TO #2 OF 9V DC INDICATING THAT THE OVERLOADS ARE STUCK OPEN.

(A) ALL SWITCHES IN THE PROPER POSITIONS:

(1) POINT 8 TO 2 ANTICIPATED 120 VOLTS
ACTUAL 120 VOLTS

(2) POINT 11 TO 2 ANTICIPATED 120 VOLTS
ACTUAL 120 VOLTS

(3) POINT 69 TO 2 ANTICIPATED 0 VOLTS
ACTUAL 9 VOLT DC

(C) OVERLOADS CLOSED

(D) RECOMMENDATION SHOULD BE TO REPLACE THE OVERLOADS AND DETERMINE IF IT WAS A MOMENTARY OR CONSTANT OVERLOAD THAT CAUSED THE CONDITION.

NOTE: IF THERE WERE NO OVERLOAD PROBLEM, THE LOGIC BOX SHOULD BE REPLACED. STUDENT SHOULD BE INFORMED OF THIS.

PROBLEM #8

S1 CONTACT IS BLOCKED OPEN. THIS PREVENTS D1 FROM CLOSING.

(A) STUDENT SHOULD CHECK FOR VOLTAGE AT POINT 8 TO 2 AND EXPECT TO READ 120 V AC. HE WILL GET THIS READING.

(B) POINT #16 TO #2, HE STILL READS 120 V AC.

(C) HE SHOULD SHUT OFF POWER AT THIS POINT AND TAKE AN OHMMETER READING FROM POINT #33 TO #2. THIS WILL SHOW ∞ AND INDICATES AN OPEN COIL OR OPEN INTERLOCK. SEPARATE OHMMETER READINGS ACROSS THESE TWO COMPONENTS WILL SHOW S1 INTERLOCK OPEN.

UNIT 15: SCHEMATICS: SOLID-STATE,BATTERY-POWERED

Pretest Activities

To administer a pretest give the student 13 copies of the solid-state, battery-powered diagram. Have the student use a pencil to trace the pulse flow through the system for forward direction, slow speed operation, and fast speed operation. Also, have the student explain the operation of the components in the system for each sequence that is traced.

Instructor Activities

1. LA #1 introduces the student to the solid-state, battery-powered training panel. To complete it the student will attend a demonstration that you will give. To give the demonstration, complete a full operating cycle for the panel. Use SH #1 as a guide to explaining what is happening with the circuitry during each step of operation.
2. LA #2 provides the student with a further explanation of the circuitry on the solid-state, battery-powered training panel. To complete it the student will need a copy of SH #1 and the 13 diagrams that accompany it. Check or have the student self-check responses to the Stud Questions.
3. LA #3 provides practice for the student in tracing pulse flow through the solid-state, battery-powered system for various operational steps. To complete it the student will need 13 clean copies of the solid-state, battery-powered diagram. Check the student's work after each operational step is traced. Have any errors corrected.

4. LA #4 provides the student practice in explaining the operation of the solid-state, battery-powered circuitry. To complete it the diagrams from LA #3 are needed. Have the students practice until they are ready for the Examination.

ANSWER SHEET

STUDENT HANDOUT #1

UNIT 15: SCHEMATICS: SOLID-STATE, BATTERY POWERED

1. CAPACITOR CHARGE REVERSE BIAS ON SCR #1
2. TO CHARGE THE CAPACITOR WITH OPPOSITE POLARITY
3. THE FIRING SEQUENCE IS FASTER, WHICH DELIVERS MORE BATTERY CURRENT TO THE MOTOR.
4. INDUCTIVE ACTION OF MOTOR FIELDS
5. IT ALLOWS THE CAPACITOR TO CHARGE.
6. SCR #1 MUST BE FORWARD BIASED BEFORE IT WILL GO INTO CONDUCTION.
7. SCR #2, #1, AND #3
8. RAPID PULSING OF THE SCR CIRCUIT IS PERMITTING NEAR-MAXIMUM CURRENT TO THE MOTOR BEFORE THE BYPASS CLOSES, ALLOWING SMOOTH TRANSITION OF POWER.

UNIT 16: BELT STARTER COMPONENTS

Pretest Activities

To administer a pretest you need to tag ten major components on the belt starter training panel. The student will be asked to identify these components. The Examination form can be used by the student to record responses.

Instructor Activities

1. LA#1 introduces the student to solid-state controls used with three-phase motors. To complete it the student will need SH #1.
2. LA # 2 introduces the student to the major components on the belt starter training panel. To complete it the student will need SH #2, the arrangement diagram that accompanies SH #2, and access to the belt starter training panel.
3. LA #3 provides the student with practice in recognizing and naming the major components on the belt starter training panel. To complete it the student will need the arrangement diagram from LA #2 and access to the belt starter training panel. Have the students practice until they are ready to complete the Examination.

UNIT 17: SCHEMATICS: BELT STARTER

Pretest Activities

To administer a pretest provide the student with copies of diagrams of the control circuit and power circuit for the belt starter training panel. Have the student trace with a pencil the pulse flow through both circuits. Also, have the student explain the operation of each circuit.

Instructor Activities

1. LA #1 introduces the student to the operation of the control circuit on the belt starter training panel. To complete it the student will need SH #1, the accompanying control circuit diagram, and access to the belt starter training panel. Check or have the student self-check responses to the Study Questions.
2. LA #2 introduces the student to the operation of the power circuit on the belt starter training panel. To complete it the student will need SH #2, the accompanying power circuit diagram, and access to the belt starter training panel. Check or have the student self-check responses to the Study Questions.
3. LA #3 provides the student with practice in tracing and explaining the operation of the control and power circuits on the belt starter panel. To complete it the student needs a copy of each circuit diagram. Check all tracing, and have any errors corrected. Have the student explain the operation of the circuits to another student.

STUDY QUESTIONS
ANSWER SHEET

UNIT 17: SCHEMATICS: BELT STARTER

1. 4
2. MASTER SENSOR CARD; LAST ONE ON RIGHT
3. 2, 3, 5
4. MONITORS LINE CURRENT AND DETERMINES ACCELERATION RATE OF MOTOR

ANSWER SHEET
STUDY SHEET #1

1. Six SCR System
2. C
3. Off Delay (or when deenergized)
4. 115 volts (may vary some depending on primary voltage)
5. Belt Slip Relay Contacts and Belt Slip Timer Contacts
6. Any of those listed in part IV of the lecture outline.
7. C, B, A
8. Sequence Switch is by-passed
9. E

UNIT 18: CIRCUIT CONNECTIONS: BELT STARTER

Pretest Activities

To administer a pretest you need to provide the student with access to the belt starter training panel, an AC motor, a three-phase AC power source, hand tools, circuit diagrams from Unit 17, SH #1, and the assigned Micronta Multitester. In most cases this will mean that you need to disconnect the belt starter training panel from the motor and the power source and disconnect the external control switches. The task is to have the student connect the panel, motor, power source, and external control switches.

Instructor Activities

1. LA #1 introduces the student to major procedures associated with belt starter panel installation. To complete it the student will need SH #1.
2. LA #2 provides the student with practice in connecting the belt starter training panel, motor, power source, and external control switches. To complete it the student will need access to the belt starter training panel, hand tools, diagrams from Unit 17, SH #1, and the assigned Micronta Multitester. The motor, power source, and external control switches need to be disconnected before the student begins work.

UNIT 19: TROUBLESHOOTING: BELT STARTER

Pretest Activities

To administer a pretest give the student access to the belt starter training panel, the assigned Micronta Multitester, hand tools, diagrams from Unit 17, and the Troubleshooting Guide. You need to present the student with troubleshooting problems to correct. Two or three will be sufficient. In each case you will need to induce the necessary faulty condition in the belt starter panel. The troubleshooting problems can be the same as those presented to the student for practice or they may be equivalent problems.

Instructor Activities

1. LA #1 introduces the student to major meter readings associated with the belt starter training panel. To complete it the student will need SH #1, the assigned Micronta Multitester, diagrams from Unit 17, and access to the belt starter training panel. Check the student's responses to the first part of SH #1. Check each meter hookup before allowing the student to make the meter readings.
2. LA #2 introduces the student to troubleshooting procedures for the belt starter training panel. To complete it the student will need the assigned Micronta Multitester, diagrams from Unit 17, the Troubleshooting Guide, and access to the belt starter training panel. Check or have the student self-check responses to the problems at the end of SH #2.

3. LA #3 provides the student practice in troubleshooting the belt starter training panel. To complete it the student needs a troubleshooting problem (which you should select), the assigned Micronta Multitester, hand tools, diagrams from Unit 17, the Troubleshooting Guide, and access to the belt starter training panel. You need to induce the fault in the training panel that will establish the troubleshooting problem. Check the student responses on the problem sheet.
4. LA#4 allows the student additional practice in troubleshooting the belt starter training panel. Proceed as described in #3 above.

ANSWER SHEET FOR
TROUBLESHOOTING PROBLEMS

UNIT 19: TROUBLESHOOTING: BELT-STARTER

PROBLEM # 1 - CAUSE: NO VOLTAGE TO LOAD SIDE OF MAIN CIRCUIT BREAKER.

PROBLEM # 2 - CAUSE: LOOSE FIRING CARD.

PROBLEM # 3 - CAUSE: TWO SCR'S SHORTED IN TWO DIFFERENT PHASES.

PROBLEM # 4 - CAUSE: MASTER SENSOR CARD NEEDS ADJUSTMENT.

PROBLEM # 5 - CAUSE: MASTER SENSOR CARD NEEDS ADJUSTMENT.

PROBLEM # 6 - CAUSE: BAD RESISTOR/CAPACITOR.

PROBLEM # 7 - CAUSE: NO INPUT VOLTAGE TO CARD RACK.

PROBLEM # 8 - CAUSE: DEFECTIVE OR OPEN GATE LEAD TO SCR'S IN ONE PHASE.

PROBLEM # 9 - CAUSE: BAD FUSE AND OVERLOAD SWITCH ACTIVATED.

PROBLEM #10 - CAUSE: ALL SCR'S SHORTED.

UNIT 20: SOLID-STATE, BATTERY-POWERED: COMPONENTS

Pretest Activities

To administer a pretest distribute Examination #1, monitor student performance, and check student responses. To prepare for the first part of the Examination, you need to tag 15 major components on the solid-state, battery-powered panel with numbers.

Instructor Activities

1. LA #1 introduces the student to the names and functions of major components on the solid-state, battery-powered panel. To complete it the student will need SH #1, the diagram that accompanies SH #1, and access to the solid-state, battery-powered panel.
2. LA #2 provides the student with practice in recognizing and locating the major components on the solid-state, battery-powered panel. To complete it the student will need SH #1, and access to the solid-state, battery-powered panel and another student.
3. LA #3 provides the student with added information on the function and purpose of major components on the solid-state, battery-powered panel. To complete it the student needs SH #2, the two diagrams that accompany SH #2, and access to the solid-state, battery-powered panel. Check or have the student self-check responses to the Study Questions.

ANSWER SHEET
STUDENT EXAMINATION #1

UNIT 20: SOLID-STATE, BATTERY POWERED: COMPONENTS

1. B

2. B

3. BY PLACING MASTER CONTROL SWITCH IN FORWARD OR REVERSE POSITION

4. TO PROVIDE A REVERSE BIAS CONDITION TO TURN "OFF" THE "MAIN" SCR

5. SC CONTACTOR

6. A

7. WHEN ACCELERATOR IS FULLY DEPRESSED, IT CLOSES. THIS CONNECTS THE NEGATIVE POWER LEAD DIRECTLY TO THE FORWARD OR REVERSE CONTACTORS.

ANSWER SHEET
FOR
STUDY QUESTIONS

UNIT 20: SOLID-STATE, BATTERY POWERED: COMPONENTS

1. A. MAIN B. OFF C. REVERSAL
2. MAIN
3. FALSE, THE LOGIC UNIT IS ALSO NEEDED TO SUPPLY THE SIGNAL AS TO WHEN THE FIRING CIRCUITS SHOULD TRIGGER THE SCR'S.
4. FS-1
5. FS-2
6. 0
7. MAIN

UNIT 21: SOLID-STATE, BATTERY-POWERED: TROUBLESHOOTING

Pretest Activities

To complete a pretest the student will need access to the solid-state, battery-powered panel, the assigned Micronta Multitester, hand tools, diagrams from Unit 20, and the Troubleshooting Guide. You need to present the student with troubleshooting problems. Two or three should be sufficient. The problems may be the same as those used for practice or they may be equivalent. In each case you need to induce the faulty condition in the panel necessary to create the troubleshooting problem.

Instructor Activities

1. LA #1 introduces the student to troubleshooting procedures for the solid-state, battery-powered panel. To complete it the student will need SH #1 and access to the solid-state, battery-powered panel. Check or have the student self-check responses to problems at the end of SH #1.
2. LA #2 provides the student with practice in troubleshooting the solid-state, battery-powered panel. To complete it the student will need a troubleshooting problem (which you should select), access to the solid-state, battery-powered panel, the assigned Micronta Multitester, hand tools, diagrams from Unit 20, and the Troubleshooting Guide. You need to induce the faulty condition in the panel to create the troubleshooting problem. Check the student's responses to items on the problem sheet.
3. LA #3 provides additional troubleshooting practice for the student with the solid-state, battery-powered panel. Proceed as described in #2 above.

ANSWER SHEET FOR
TROUBLESHOOTING PROBLEMS

UNIT 21: SOLID STATE, BATTERY POWERED: TROUBLESHOOTING

PROBLEM # 1 - CAUSE: BOTH 20-AMP CONTROL FUSES "BAD."

PROBLEM # 2 - CAUSE: OPEN CIRCUIT IN CONTROL WIRING TO FORWARD CONTACTORS.

PROBLEM # 3 - CAUSE: LINKAGE ON MICROSWITCH (FS-2) OUT OF ADJUSTMENT.

PROBLEM # 4 - CAUSE: SHORTED SCR #2.

PROBLEM # 5 - CAUSE: "BAD" CAPACITOR.

PROBLEM # 6 - CAUSE: DEFECTIVE FLYWHEEL DIODE.

PROBLEM # 7 - CAUSE: OPERATING COIL FOR REVERSE CONTRACTOR DEFECTIVE.

PROBLEM # 8 - CAUSE: SC BY-PASS CONTACTOR DEFECTIVE AND SCR FUSE "BAD."

PROBLEM # 9 - CAUSE: POTENTIOMETER IN FOOT SWITCH NEEDS ADJUSTMENT.

PROBLEM #10 - CAUSE: SHORTED SCR #3.

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